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CATERPILLARS.—V.

By E. A. Butler.

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THAT the colours of caterpillars have some sort of relation to their surroundings is a conclusion at which one would be able to arrive after even a limited experience in the woods and fields. Thus it would soon be discovered that those larvæ that feed in the stems of plants or the trunks of trees, or in roots, or between the skins of leaves, are mostly pale whitish or yellowish, and that those that dwell in the seclusion of a coiled-up leaf are chiefly of a dirty greenish or yellowish white without distinct markings. On the other hand, it would be found that those that feed in the open are much less uniform in tint, and are often brightly variegated, or at least decidedly coloured, and marked not unfrequently with distinct and intricate patterns of exquisite hues, in sharpest contrast with one another—patterns, indeed, which might often be worth the attention of students in a school of art, for the suggestion and elaboration of artistic designs. Moreover, speaking again only of those caterpillars that feed exposed, one of the earliest generalizations the practical naturalist feels himself in a position to make is, that the two colours to which, out of all the variety of Nature's extensive *répertoire*, the preference has been given in the vegetable world, viz., green and brown, are also those that prevail in the caterpillar world, while some others, such as blue, for example, are very rarely to be met with. And, as such caterpillars spend their life amongst vegetation, some on the leaves, others in closer proximity to the stems and branches, it is not unreasonable to conclude that the prevalence of green and brown in their skins is due in some measure to the state of affairs found in the vegetable world; for the assimilation of the insect to the aspect of its surroundings would render it less conspicuous, and would probably, therefore, to some extent protect it from foes which might otherwise jeopardize its existence.

But after all, such a conclusion only pushes the enquiry a stage farther back, for, if we accept it, we then need to enquire why these two particular colours are also the dominant ones in the vegetable world; it cannot here be a case of the imitation of environment, but some other and perhaps more obscure reason would seem to underlie the fact. And here, whatever may have been the case before, we get most distinctly into the regions of chemistry and physiology, for the green colour of plants is due to the presence in their tissues of a particular substance called chlorophyll, and the presence of this is again due to physiological changes in the plant brought about through the influence of the sun's rays, so that again the enquiry would be pushed back a stage, for we should need to ask why chlorophyll is green. While, therefore, it will be a distinct advance in knowledge if it can be shown that the colours of certain living beings are to any extent determined by those of the inanimate objects around them, we must not lose sight of the fact that this is by no means the end of the matter, that we have advanced but one step along the path of truth, and that many more may be necessary before it is possible to establish in all their completeness the connections that exist between the forces of Nature and the present conditions of the various animate and inanimate organic bodies we see around us.

Bearing these cautions in mind, then, we may proceed to consider in a little more detailed way, some of the chief facts connected with the colours and markings of caterpillars. If the colours of caterpillars are affected by their surroundings, it would appear that the result would be produced in one or other of two ways, either by the colour of the food itself affecting that of the tissues of the body and the blood, and this colour then appearing through the transparent skin, or, on the other hand, by the presence of some sensitiveness in the individual, which enables it unconsciously to respond to the nature of the light falling upon it from surrounding objects, and produce pigments of one colour under the influence of light of one kind, and of another colour with a preponderance of light of a different kind. Caterpillars feeding upon green leaves, and having thin transparent skins, might thus, on the first hypothesis, be expected to show a tendency towards a green colour, and this has been proved in some cases to account for the greenness of larvæ. Indeed, when such larvæ are not green, it is not necessarily through the absence of that colour in their tissues, but often merely because it is concealed by other pigments deposited in the skin. These facts have been established by Mr. Poulton, by means of a series of very elaborate experiments, which lead also to the second hypothesis mentioned above.

To determine this latter point, namely, the influence which the surroundings exercise by their mere presence, he experimented with several kinds of larvæ, but especially with those of the pepper moth (*Amphidasis betularia*), as this proved to be by far the most susceptible to external influences, and therefore the best for experimentation. The food uniformly supplied being the leaves of the black

poplar, a large number of the larvæ were separated into groups, which were placed in different receptacles. Of course in all it was inevitable that there should be a certain amount of green surroundings, because of the leaves of the food plant; but the circumstances were varied by the introduction of other objects. For example, to give a preponderance of dark surroundings there were introduced a number of very dark twigs from a kind of oak tree, together with stems of other kinds, all dark but of different tints in the different cases. Spills made of dark-coloured paper, and artificial leaves, or natural dead leaves, were also used, being stuck about amongst the food plant. In the case of the light surroundings, there were, besides the leaves of the food plant, green twigs, and spills of white or light-coloured paper. The caterpillars were introduced into these special surroundings when about half-grown, as that was found to be, on the whole, the most susceptible age. The general results of a large series of experiments (Fig. 15) were that the majority of those amongst the dark surroundings tended to become darker than when introduced, developing some shade or other of brown—such, namely, as best harmonized with the exact tint of the dark objects used, while in the experiments with light surroundings the reverse was the case, and the larvæ became pale green or other light colour, some of the most remarkable results being produced where the white spills were used. It thus seems to be established that, in the case of some insects at least, the colour of their environment has an important influence in determining their own colour. But it must also be admitted that there are many species amongst those experimented upon, which show very little of such susceptibility, so that the final determination of colour in many instances is probably a somewhat intricate matter, and dependent upon many different conditions.

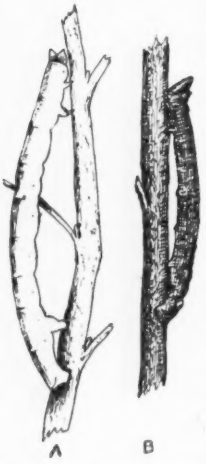

Fig. 15.—Larvæ of Pepper Moth (*Amphidasis betularia*). A. Green specimen on green twig; B. Brown specimen on brown twig. (After Poulton.)

Recognizing, however, as we seem bound to do, that the surroundings do constitute a possible factor in determining the colour of the caterpillar, we may even take one step farther and suggest that the general pattern, as well as the mere colour of the surroundings, may also be reproduced in the skin of the caterpillar. It is not difficult to call to mind many curious facts illustrating such connection between the pattern of the caterpillar's ornamentation and the prevalent features of its environment. For example, the larvæ of the butterflies of the family *Satyridæ*, such as the familiar meadow browns and heath butterflies, which feed on grasses, are striped longitudinally with dark and pale lines. Now it is obvious that in a spot where a quantity of tall grass is growing, longitudinal lines of shading and colouring, caused by the ribs and veins, stems and leaves of the grasses, and the shadows they produce, will be artistically the predominant feature; and then we find that the caterpillars which live in such spots partake of the prevailing style of colour-arrangement too; while, to put the converse fact, those caterpillars that feed upon broad-leaved plants, in which such longitudinal effects of light and shade will be much less conspicuous, if present at all, are usually found, though still possessing some pale longitudinal lines, not to have them so prominent or occupying so much of the surface. These can hardly be mere coincidences.

When oblique stripes are present it is in species which feed on broad-leaved plants; and as the venation of leaves of this kind is of a different type from that of grasses, the chief veins branching from the midrib at an angle, instead of running more or less parallel to the edge of the leaf, the oblique stripes on the caterpillars have been supposed to be a sort of reflection of the obliquity of the veins of the leaf, especially as there is often present on the caterpillars a longitudinal line as well, just beneath or running through the oblique stripes, suggestive of the midrib of the leaf. However, as it is only in a small proportion of cases amongst those that feed upon plants whose leaves are veined in this way that such ornamentation holds, and by far the greater number show no trace of diagonal lines, the case for imitation is a far less strong one than that of the longitudinal striping. The most remarkable instances of oblique striping are to be found amongst the caterpillars of the hawk moths, many of which exhibit it in the highest degree, thereby greatly enhancing their beauty. Nothing can be more harmonious, for instance, than the coloration of the larvæ of the privet hawk moth, one of the commonest of the group; in this insect the ground colour is a beautiful tint of green, and the stripes, which are seven in number on each side, are white edged with a band of the purest lilac on the upper margin. The huge caterpillar of the death's head moth is another very remarkable instance; its stripes are pale blue on the back, but farther down they deepen into black and are edged with yellow.

But the greatest interest attaches to that peculiar style of ornamentation called "eye-spots." These are large circular patches of concentric rings of colour, which occur only in a very few caterpillars, and irresistibly suggest the eyes of some vertebrate animal. The true eyes of the caterpillar, it will be remembered, are practically invisible except on a close inspection, and there is nothing, therefore, to compete with these spots or neutralize their effect. By far the best illustration of this type of ornamentation that we meet with in this country is to be seen in the larva of the elephant hawk moth (*Chærocampa elpenor*) (Fig. 16). It feeds on the common hairy willow-herb of damp ditches and river sides, a plant which, from its gay clusters of large pink flowers and its habit of growing in dense clumps to the height of four or five feet, is one of the first of summer wild plants to attract attention, and must be well known to everybody. The caterpillars may also sometimes be found in gardens feeding on fuchsias.

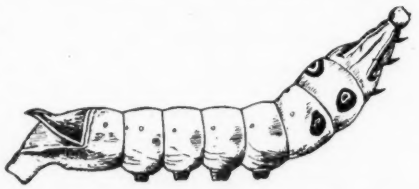

Fig. 16.—Larva of Elephant Moth (*Chærocampa elpenor*) in its last stage, slightly reduced.

These larvæ are interesting in many respects. They are of the type known as dimorphic, *i.e.*, like those of the pepper moth they have two varieties when fully grown, a green one and a brown one, a circumstance which, according to Mr. Poulton, betokens a ready adaptability in the insect to colour changes in its surroundings. At first, however, they are all green, and during the early part of their life they remain amongst the leaves of their food plant when not eating, thereby availing themselves of the concealment afforded by the harmonizing of their colour with that of the foliage around them. But when

they reach their fifth stage, a great change comes over them. The casting of the skin on this occasion leaves them, not green as heretofore, but with a coat of brown instead; this at least is what happens to the majority, though some few erratic individuals still retain their juvenile greenness, which, indeed, they never lose. Concurrently with this change in colour there is an alteration of habit; they now no longer rest amongst the fresh foliage of the food plant, but descend to the ground when not feeding, where their changed colour is as efficacious in concealing them amongst the dead leaves, stems, and brown soil, as it would have been in exposing them had they remained embosomed in green.

But this is not the only peculiarity. When first hatched they have no markings of any kind, but after the first change of skin, which takes place when they are five or six days old, they appear with two longitudinal white lines stretching the whole length of the body. At this time they are utterly unlike what they will ultimately become. After a few days, the upper line, in the region of the fourth and fifth segments behind the head, begins to show signs of irregularity, a slight swelling appearing in each of these segments. These are the commencements of the eye-spots, though from their present appearance it would be quite impossible to predict what they might become; indeed, they are most inconspicuous, and only to be noticed at all by a careful inspection. By another moult they pass into their third stage, when it is observed that the lower line has disappeared, and the two white swellings have become larger, and are now recognizable as distinct spots. After the next moult, the most noticeable change is that the incipient eye-spots are larger and are now surrounded by a black line. Again in the next stage, the fifth, and last but one, the spots are much larger, the black margins being spread out into a broad patch, and the white reduced to a ring by the appearance of a violet spot in its centre, so that it now begins to look something like an eye. At the same time, the longitudinal lines become almost obliterated and *diagonal* ones take their place. In the final stage all these points are still more emphasized, and at the same time, the third and fourth segments, which at first were no larger than the rest, have become considerably swollen, while the head looks disproportionately small, having grown hardly so much as might have been expected. Hence the caterpillar suddenly bulges out in the third and fourth segments, and this becomes all the more marked when the head is drawn back. By this movement the eye-spots on the fourth segment are brought into great prominence, and the whole of the front of the insect acquires a slight resemblance to a snake's head, with staring, stony eyes. The effect, even upon those who are familiar with the insect, is really quite startling, and it is difficult to persuade oneself that those glaring orbs are not really eyes with the most cruel and penetrating glance.

Now these eye-spots are unquestionably of considerable use to the insect; for, suggesting as they do a dangerous animal which it will be as well not to molest, they warn off any but the hungriest or most knowing of enemies, and save their possessor's life. And well the poor creature needs such a defence, for it appears to be a decidedly palatable morsel to insectivorous vertebrates. There is direct evidence, too, that the above suggestion of the function of the eyespots is not mere imagination. Dr. Weismann, who has made a particular study of the colour and markings of the *Sphingidæ* in general, was especially interested in this species. He had an enclosure for fowls which was open above, so that wild birds could easily fly in, and this they were often accustomed to do whenever the fowls were not there. On one occasion Weismann put a large brown larva of the elephant moth in the food trough, after having removed the fowls. Flocks of sparrows and chaffinches soon flew down as usual, and alighted near the trough in the hope of picking up grain or other stray food. One bird soon flew on to the edge of the trough, and was about to hop into it, when it caught sight of the caterpillar. This deterred it, and it stood jerking its head enquiringly from side to side, but did not venture to go any nearer. One after another, about a dozen of the birds acted in the same way; when, however, the caterpillar was removed, they hopped into the trough briskly enough. The fowls themselves behaved somewhat similarly. When a specimen was placed in their midst, they at first ran hastily towards it, evidently in expectation of a feast, but as soon as they came near to it, they stopped and ran round it irresolutely, and it was not till after something like a score of half-hearted attempts to seize it, in each of which courage had failed at the last moment, that one more courageous than the rest at last reached the insect, and finding that nothing serious happened, pecked away at it till it was demolished. Caterpillars of ordinary appearance were, of course, swallowed at once without any difficulty. A domesticated jay was much more plucky, and swallowed the elephant caterpillar as soon as it was offered; but as domestication has the effect of taking off much of the shyness of birds in other respects, it is possible that this boldness may have had a similar origin, and that the bird would not have acted thus in the wild state.

We have not space to pursue this subject further, but can only indicate the general conclusions which seem to follow from the experiments and observations mentioned in this paper. These are, that the colours and patterns of caterpillars are not accidental, but have an intimate relation to their circumstances; that they can, at least in some cases, be modified by their environment, and that many have thus become useful to their possessors, whereby again they tend to be perpetuated; and finally, that the order in which the changes of colour and pattern appear in the life of the individual specimen is also that in which they have been acquired in the life of the species, so that the progressive changes observable in the present-day caterpillar's individual experience reveal something of the facts which constitute the past history of the generations which have preceded it.

DEEP SEA DEPOSITS.

By REV. H. N. HUTCHINSON, B.A., F.G.S., *Author of "Extinct Monsters."*

[FIRST PAPER.]

THE wish to know something of what goes on "at the bottom of the deep blue sea" is a very natural one, but until late years the bed of the ocean has been a *terra incognita*. Popular imagination, however, fastens itself more on the sunken treasures and dead men's bones than on the natural phenomena and life of the deep sea. We propose, however, to consider only the scientific aspects of the subject, and to endeavour to lay before the reader a brief account of the deposits now in process of formation on the bed of the sea. Recent deep sea dredging expeditions have opened out a new world to the naturalist, the geologist, and the geographer. Of this new world we will endeavour to give a few glimpses, though the light at present thrown on it is only as moonlight to sunlight. Within the last thirty or forty years many ships belonging to different nations have, by means

of dredgings and soundings, made a large number of observations bearing upon the depths of the oceans in different places, the deposits forming, the forms of life flourishing there, and many other interesting questions. But of all such expeditions that of H.M.S. *Challenger* has been the most fruitful. The *Challenger*, with its able staff of naturalists, chemists, and others, under the direction of the late Sir C. Wyville Thomson, left England in 1872. The cruise lasted three and a half years, and since she returned a large number of most valuable and exhaustive reports have been issued. The last of these, published in 1892, deals with deep sea deposits, and is the first attempt ever made to deal *with such deposits systematically*. It treats of the geology of the sea bed throughout the whole extent of ocean. The authors are Mr. John Murray, naturalist of the *Challenger* expedition, and the Rev. A. F. Renard, Professor of Geology in the University of Ghent. Our remarks will be chiefly based upon this most excellent report. But, before forming their conclusions, the authors have studied samples obtained by other expeditions, so that the results arrived at are all the more firmly established. Since the return of H.M.S. *Challenger* very many samples of marine deposits have been collected from nearly all regions of the ocean basins by various ships. The great majority of these have been examined by them, so that altogether they obtained a very large amount of material.

Of pelagic or true ocean deposits, as distinguished from the coarser terrigenous materials laid down nearer to the shores, more than 2000 samples (from depths exceeding 1000 fathoms) have passed through their hands. Indeed, so great is the experience of ocean deposits they have thus gained, that they can even guess with a good deal of certainty the region from which a sample submitted to them came, as well as state approximately the depth and distance from land at which it was procured. To test this, they frequently asked their assistants to select a sample for them (without giving any clue as to where it came from), and they found that, in nine cases out of ten, they could state the position within a few hundred miles, and the depth to within a few hundred fathoms!

In all parts of the ocean where the slope of the sea bed is not precipitous, and where no strong currents sweep over it, the rocky bed (supposed to be the original cooled crust of the earth—in some of the deepest parts) is covered with a mantle of deposits of various thickness, to which the gently-rounded contour of the ocean beds is largely due. Readers of Knowledge will scarcely need to be reminded that, broadly speaking, these deposits consist of (1) sands, gravels and muds (mostly formed near shore); (2) finer muds (further out to sea) passing gradually, as the depth becomes greater, into (3) various organic oozes, such as the well-known "globigerina ooze," which takes its name from a very abundant little foraminiferal shell known as globigerina (on account of its globular shape); and lastly (4) the equally well-known "red clay," found in all the deepest depressions of the oceans. And now arises the question of classification, which is not a very easy one. Messrs. Murray and Renard, however, point out that these ocean deposits may be classified either as regards geographical position, or as regards composition, as well as position and depth. In the first case we have the following scheme:—(1) Deep sea deposits; (2) Shallow water deposits between the 100-fathom line and low water mark; (3) Littoral deposits, formed between high and low

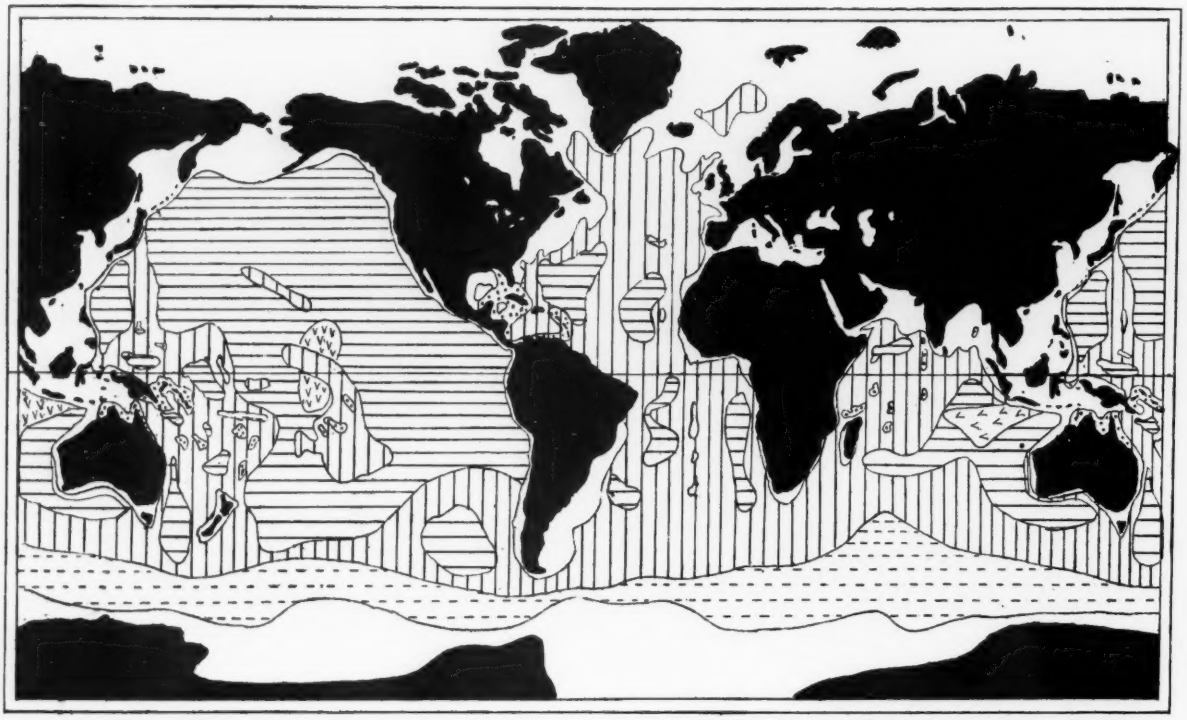

Chart I. Ocean Deposits.—*Explanation.*—The white space bordering lands marks the region of Terrigenous Deposits; vertical lines mark Globigerina Ooze; horizontal lines mark Red Clay; broken horizontal lines mark Diatom Ooze; two areas marked thus $^{v}_{v}{}^{v}_{v}$ mark Radiolarian Ooze; dotted spaces mark Coral Sands and Muds; a few small white spaces mark Pteropod Ooze.

water mark. In the second the arrangement would be as follows:—(1) Pelagic deposits—those formed towards the centres of the great oceans, and chiefly made up of the remains of pelagic organisms (foraminifera, radiolaria, pteropod shells, diatom frustules), along with the ultimate products arising from the decomposition of volcanic rocks and minerals, viz., the red clay; (2) Terrigenous, or land-derived, deposits—those formed close to continents and islands, and largely made up of transported materials—gravels, sand, muds, &c. The relations of these two groups to each other, and their subdivisions, are shown in the following scheme which the authors have put forward as the first attempt at a systematic classification, and which combines the two methods above mentioned.

1. Deep sea deposits, beyond 100 fathoms.	Red Clay. Radiolarian Ooze. Diatom Ooze. Globigerina Ooze. Pteropod Ooze.	I. Pelagic deposits, formed in deep water removed from land.
	Blue Mud. Red Mud. Green Mud. Volcanic Mud. Coral Mud.	II. Terrigenous deposits, formed in deep and shallow water close to land masses.
2. Shallow water deposits, between low water mark and 100 fathoms.	Sands, gravels, muds, &c.	
3. Littoral deposits between high and low water mark.	Sands, gravels, muds, &c.	

As we are dealing with deep sea deposits, it will not be necessary to dwell upon those formed in shallower waters (2 and 3). Their characters are well known to all students of geology. They are chiefly due to the action of rivers transporting *débris* worn off the land; but they pass at their lower limits into deep sea deposits, and all through show the results of mechanical action. Vegetable and animal life abounds. They occupy about 10,000,000 square miles of the earth's surface out of a total of 196,940,700.

Passing on to No. 1, it should be pointed out at once that, for various reasons, Messrs. Murray and Renard include in the term deep sea deposits *all* deposits formed at depths beyond 100 fathoms. This may seem at first a little extreme, for the 100-fathom line, as geographers know, runs very near all the coasts. But this line is one that is well known on our charts, and, secondly, this submarine contour line appears to mark the depth at which (on the average) most of the fine amorphous land-derived particles begin to settle down, so that beyond this line are found chiefly fine muds, or organic oozes. Also, at about this depth deposits become more uniform, and signs of mechanical action are much less evident. Between this line and the coasts the deposits are much coarser and more variable.

Referring to the scheme given here, it will be observed that even deep sea deposits are, some of them, terrigenous or land-derived, and not all organic oozes or red clays. But by choosing a lower limit of depth, it would be easy to make a scheme in which all deep sea deposits were either the one or the other. However, by taking the 100-fathom line, the authors have been able to include in their survey many interesting deposits, the study of which throws light on some important geological problems.

As a rule, all land-derived material falls on to the bed of the ocean within 100 or 200 miles of the shore; but in some exceptional cases it may float on to 300 miles or more from the coast. A line drawn 250 miles from all our coasts

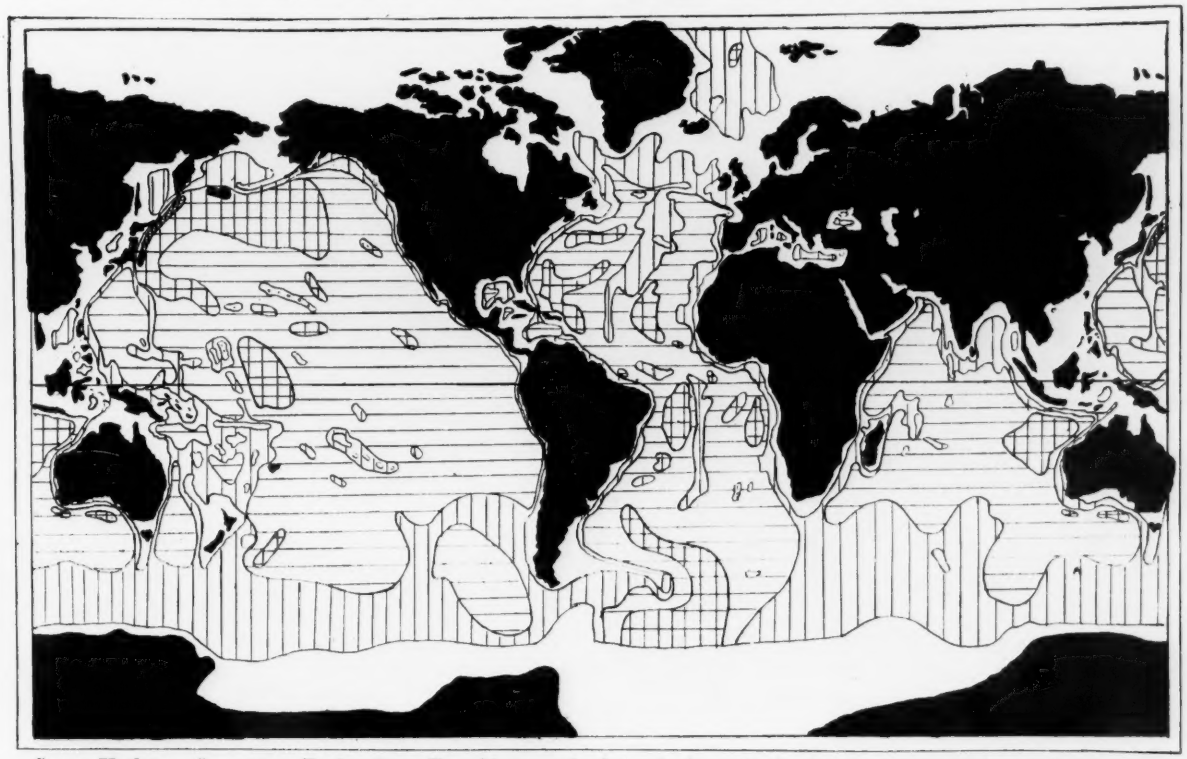

CHART II. OCEAN CONTOURS.—*Explanation.*—The white space bordering lands marks the shallow waters up to 1000 fathoms—the 100 fathom line (not shown) runs near this; vertical lines mark 1000 to 2000 fathoms; horizontal lines 2000 to 3000 fathoms; squares 3000 to 4000 fathoms; fine cross over 4000 fathoms.

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would practically mark the boundary between terrigenous and pelagic deposits. Very large and swift muddy rivers, like the Congo and the Amazon, however, cause the former to travel to even greater distances. The work of icebergs makes another exception to this rule; for they drop stones and mud all along the path of the ocean currents which drift them into warm seas, thus tending to some extent to confuse the limits of terrigenous and pelagic deposits. Winds also blow desert sand and fine volcanic ashes for hundreds of miles out to sea. Still, the broad distinction remains.

Before passing on to consider somewhat in detail the nature and origin of some of the deposits mentioned in the above scheme, let us look for a moment at their geographical distribution, as well as the depths at which they occur. It is estimated that terrigenous deposits cover one-fifth of the area of the oceans (or one-seventh of the earth's surface); so that the pelagic deposits occupy four-fifths of the ocean bed (or four-sevenths of the earth's surface—the land occupying two-sevenths).

Charts I. and II. have been reduced by photography from two larger drawings made by the author. No. I. is a generalized form of the map in the report of Murray and Renard, and No. II. is based on a map by J. Bartholomew. The first shows at a glance the distribution of the principal marine deposits, the second shows the depth of the ocean, as far as known at present; and it is instructive to compare the two charts in order to see how far depth is a factor in determining the character of the deposits lying on the sea floor. It will be apparent at once that, broadly speaking, depth *is* the chief factor, although other causes (such as latitude and temperature) have their influence. Take, for example, the distribution of the globigerina ooze* (shown by vertical lines) and you will see how it occupies the shallower parts of the Atlantic Ocean between 1000 and 2000 fathoms and between 2000 and 3000 fathoms, and parts of the Pacific and Southern Oceans between 1000 and 2000 fathoms. As we shall see in the next paper, it is most typically developed at depths between 2000 and 3000 fathoms, but its average depth is just about 2000 fathoms. Over part of the great Southern Ocean its place is taken by diatom ooze. Still, even that ooze will contain a very fair proportion of foraminifera. Look again at the large area surrounding the east of Australia and the many groups of islands to the north and east, and you will see this same ooze, &c., occupying most of this region within the depth range of 1000 to 2000 fathoms.

But the red clay brings out the importance of depth as a factor in this matter of distribution much more plainly. Take the Atlantic Ocean, and you will find four large patches of this deposit, lying in four or more hollows where the depth (shown by cross lines) is 3000 to 4000 fathoms—two on each side of the well-known ridge that runs straight down the Atlantic. Taking the Pacific, we find red clay in a depression off the south-west coast of South America, with globigerina ooze surrounding it where the depth is less. The greater part of the Pacific we see has red clay, the globigerina ooze confining itself to the shallower waters (1000 to 2000 fathoms) nearer land, or groups of islands. The long and rather wide strip of diatom ooze in the southern hemisphere is peculiar, and its presence there must be explained by other causes. So with the two patches of radiolarian ooze—one in the Indian Ocean, and the other in the centre of the Pacific (marked in Chart I. by little marks like a v). The dotted spaces mark coral mud, derived from the wear and tear of coral reefs, and their positions can easily be accounted for; but even these are partly limited by depth. The three little plain spaces on the ridge of the South Atlantic denote pteropod ooze, and there is another one between New Zealand and the Equator.

The areas around the continents and islands in which terrigenous deposits are being laid down is marked in Chart I. by a plain white area, and it need hardly be pointed out that depth is the chief factor in determining the areas over which they spread.

But it must not be supposed that the boundaries of the various deposits are as accurately known as might be implied by the definite bounding lines shown in Chart I. In reality, these deposits shade off one into the other in a gradual manner, such as should be indicated by shading rather than by sharp lines. It is necessary also to add that some of these bounding lines are more or less hypothetical in places, and have been got by filling in outlines suggested by mapping down the results of sounding and dredging operations. So with regard to the ocean contours; they are not yet fully mapped out, as our knowledge of certain areas is limited. If future soundings modify some of the contour lines shown in Chart II., it is pretty certain that changes on the other Chart will be required; for, as we have shown above, depth is the chief factor in determining the distribution of deep sea deposits.

* See Knowledge, Vol. xv., p. 164.

ON CERTAIN LOW-LYING METEORS.

By Charles Tomlinson, F.R.S., F.C.S., &c.

1.—The Ignis Fatuus.

THE term "low-lying meteors" involves something like a contradiction, since the word "meteor" (μετεωρος, "high") originally referred to appearances in the upper regions of the atmosphere, such as the *Aurora Borealis*. As science advanced, the word was extended to all the varied phenomena that are connected with the weather and embodied in the term "meteorology." Our present purpose, however, is to give some details on a subject that seems to have fallen into hopeless confusion—namely, the phenomena to which the term *ignes fatui* has been applied by the English, *feux follets* by the French, and *Irrlichter* by the Germans.

Some old pupils of mine were seeking for information on the subject of the *ignis fatuus*, or "will-o'-the wisp," also known as "jack-o'-lantern," and turned to one of those popular books grandly styled "Guides to Knowledge," and read as follows:—

"This luminous appearance (which haunts meadows, bogs, and marshes) arises from gas of putrefying animal and vegetable substances, especially from decaying fish. These luminous phantoms are so seldom seen because phosphoric hydrogen is so very volatile that it generally escapes into the air in a thinly diffused state. They fly from us when we run to meet it, because we produce a current of air in front of ourselves (when we run towards the *ignis fatuus*) which drives the light gas forwards. It runs after us when we flee from it, because we produce a current of air in the way we run, which attracts the light gas in the same course, drawing it after us as we run away from it. The Welsh "corpse candles" are the same thing as the *ignis fatuus* Swarms of luminous insects passing over a meadow sometimes produce an appearance similar to the *ignis fatuus*."

This passage contains nearly as many blunders as lines. The *ignis fatuus* is not seen in meadows; it is not due to putrefying animal matter; there is no such gas as phosphoric hydrogen—the gas really meant is one of a series of inflammable compounds, in naming which the Latin word *uret* ("it will burn") is introduced, such as phosphuretted hydrogen, carburetted hydrogen, &c., but now known by the shorter terms "phosphide," "carbide," &c. As a specimen of English composition may be noted the

sentence, "They fly from us when we run to meet it." The Welsh corpse candles and the luminous insects wind up appropriately a series of mistakes.

On turning to so respectable a publication as the *English Cyclopædia* (Arts and Sciences Division), 1860, the *ignis fatuus* is described as a meteor resembling a flame, which is vaguely said to do a number of things, and may be seen over marshes and burial grounds; and the case is related in which a weak blue flame came up from the sea, and burnt some ricks of hay. It is also stated that "such meteors are most usually witnessed during a fall of rain or snow." After referring to some other cases, the writer remarks, "Little confidence can be placed in the descriptions given of them, as few persons have been able to examine them with due attention; and commonly they have been observed under the influence of an ill-regulated imagination rather than a philosophical spirit." That such meteors are due to phosphuretted or carburetted gas is termed "a plausible hypothesis," but "there is a great dearth of satisfactory observations on moving lights seen in Nature, and the entire subject is at present in obscurity."

In the ninth edition of the *Cyclopædia Britannica* the subject is treated, oddly enough, under *Phosphorescence*, which is said to be a name "given to various phenomena due to different causes, but all consisting in the emission of a pale, more or less ill-defined light, not obviously due to combustion." It is stated that the *ignis fatuus*, as seen in marshy districts, has given rise to much difference of opinion. Kirby and Spence suggested that it might be due to luminous insects, "but it is more reasonable to believe that the phenomenon is caused by the slow (?) combustion of marsh-gas."

In *Chambers's Cyclopædia* (a Dictionary of Universal Knowledge), new edition, Vol. VI., 1890, the article *Ignis Fatuus* seems to have been entirely derived from the article *Irrlichter* in the *Konversations-Lexicon*. In this there is the same uncertainty in the treatment of the subject, and the same confusion as in the earlier writers, arising from the application of the same term to meteors of very different origin. The article begins by stating that the *ignis fatuus* "is a luminous appearance of uncertain nature, which is occasionally seen in marshy places and churchyards. The phenomenon has been frequently described, but it has been observed so rarely in favourable circumstances by scientific men, that there is no satisfactory explanation." The theory that the meteor is due to ignited marsh-gas is dismissed as untenable, because the gas does not ignite spontaneously. The more plausible suggestion, that it is due to phosphuretted hydrogen, which ignites on contact with oxygen, is also rejected, on the ground that a German observer "passed his hand through the luminous appearance, and felt no warmth"; while another German "held the metal tip of a walking stick in the flame of a fixed *ignis fatuus* . . . for a quarter of an hour, but the metal was not warmed." The luminous appearances here referred to were evidently electrical, not gaseous, as was also the meteor, which was seen to "bound over the country like a ball of fire for half an hour at a time."

It is sufficiently evident that the compilers of the articles just quoted were not scientific chemists, nor had ever had any experience in laboratory practice. They seem to have derived their information from some of the older books of science, in which certain natural phenomena are attempted to be explained before the science of the subject had been discovered. Thus, previous to Franklin's great discovery of the identity of lightning with common or frictional electricity, that brilliant meteor was supposed to be due to the oil of plants evaporated during the heat of the day, and set on fire in the sky. Ignorant, too, of gases, they could not explain phenomena due to that source. What they wrote up to the science of their time they generally wrote well, but they had the unfortunate habit of explaining within the terms of their own knowledge what lay far beyond it, and which it was the function of future men of science to discover. Such a writer was Dr. Van Musschenbroek, Professor of Mathematics and Philosophy in the University of Leyden. His Latin treatise on Natural Philosophy was translated by John Colson, M.A., F.R.S., Lucasian Professor of Mathematics in the University of Cambridge, and was printed for J. Nourse at the "Lamb," without Temple Bar, 1744. The following paragraph is copied from Vol. II., p. 291:—

"§ 1329. *Wandering fires*, or *ignes fatui*, are of a round figure, in bigness like the flame of a candle, but sometimes broader, and like bundles of twigs set on fire. They sometimes give a brighter light than that of a wax candle, at other times more obscure, and of a purple colour. When viewed near at hand they shine less than at a distance. They wander about in the air, not far from the surface of the earth, and are more frequent in places that are unctuous, muddy, marshy, and abounding with reeds. They haunt burying places, places of execution, dunghills. They commonly appear in summer, and at the beginning of autumn. But in the country about Bononia they are seen throughout the whole year in a dark night. For there in a cold winter, and when the ground is covered with snow, they are in greater plenty than in the hottest summer. Those, also, are observed in winter which Gassendus says are seen at Rogon, a town of Provence. They appear more frequently in hot than in cold countries. In Italy, near Bononia, are the greatest, and in the greatest plenty. Sometimes they vanish on a sudden, and presently shine out in another place. They are generally at the height of about six feet from the ground. Now they dilate themselves, and now contract. Now they go on like waves, and rain, as it were, sparks of fire, but they burn nothing. They follow those that run away, and fly from those that follow them. Some that have been catched were observed to consist of a shining, viscous, and gelatinous matter, like the spawn of frogs, not hot or burning, but only shining, so that the matter seems to be phosphorous, prepared and raised from putrefied plants or carcases by the heat of the sun, which is condensed by the cold of the evening, and then shines. Yet I do not think that the matter of all is the same, for without doubt those of Bononia differ from those of Holland. It is a mere fiction that these fires are evil spirits, or wandering ghosts, misleading travellers out of mere spite, to plunge them into ditches and bogs, as some trifling philosophers have told us."

In the above passage there are some good descriptions of low-lying meteors, but the writer cannot reconcile the phenomena as due to one source, for he does not suppose that "the matter of all is the same." With our present knowledge it is easy to recognize, in his description, three varieties of low-lying meteors, namely, the gaseous of two kinds, and the electrical. On the present occasion we will trace the history of the *ignis fatuus* properly so-called, reserving for another article the consideration of the other two meteors.

The first step towards a true explanation of the *ignis fatuus* was taken by Priestley, who in 1767 commenced his "Experiments and Observations on different kinds of Air," and thus laid the foundation of pneumatic chemistry. Among his experiments are a considerable number on the inflammable air produced during the decomposition of various kinds of vegetable matter, and he says: "The air from marshes also, which, with Sig. Volta, I doubt not comes from putrefying vegetable substances, I have also found to be equally permanent," that is, not absorbed by water as in the case of fixed air. Volta distinctly stated that the gas from marshes is the cause of the *ignis fatuus*, and that the gas is kindled by lightning or by an electric spark.

The next step was taken by the Abbé Bertholon, Professor of Experimental Physics at Languedoc, and member of various scientific societies. In 1787 he published a work on meteors, containing a chapter on the

ignis fatuus. Taking advantage, apparently, of Priestley's discoveries—for, as he appropriately remarks, it was impossible to explain the *ignis fatuus* before gases were discovered—he proceeds to describe the following capital experiment, which we must let him relate in his own language:—

"Il est bien prouvé, par l'expérience et l'observation, que dans les marais, et les terrains marécageux, il y a de l'air inflammable; il suffit, pour en obtenir, de remuer avec une canne la vase de ces endroits, aussitôt on verra s'en échapper, à travers de l'eau qui en couvre plus ou moins la surface, une quantité assez considérable. Si dans cet instant on approche la lumière d'une bougie on verra aussitôt l'air inflammable s'allumer, et la flamme s'étendre au loin."

The gas thus formed has been collected in bottles full of water inverted in the water of the marsh with a funnel in the neck of the bottle. On stirring the mud below, the gas enters the funnel in bubbles, and, rising up, displaces the water in the bottle. It was found by Sir Humphry Davy and others to contain carbonic acid and a small quantity of nitrogen, the proportion of either or both of which would, of course, influence the character of the flame. Davy found the pure gas to consist of four parts of hydrogen in chemical union with one part of carbon, identical in composition with the fire-damp of the coal mine. It is known as marsh-gas, or light carburetted hydrogen. It is the only source of the *ignis fatuus*, properly so called. It is ignited either by lightning or by an accidental flame. I knew it in one case to be ignited by a labourer passing by a marsh lighting his pipe and throwing the match away. Another case has recently come under my notice. An old pupil of mine informed me that four or five years ago he was rowing in a boat with some friends on a pool of some three acres in extent. A stream of water flowed through it, but the pool was stagnant, or nearly so, in the rear of an island in the pool. At this spot he noticed large bubbles of gas rising and bursting, and at once surmised that they contained marsh-gas. To test this he applied a lighted match, but not taking heed as to the direction of the wind, the flame from a large bubble instead of being blown away from him was blown towards him, and burnt all the hair from off the back of his hand. Many trees grew near the spot, and leaves fell abundantly into the water, so that in the course of years the decaying matter had produced a considerable deposit of mud, which necessitated the emptying and cleansing of the pool, after which the production of marsh-gas ceased.

The *ignis fatuus* is now seldom or never seen, and the reason is that the places which produced it have been drained and brought under cultivation. Some years ago, however, Major Blesson of Berlin made a number of capital experiments on the subject in a valley in the forest of Gubitz, in the Neumarck, where the meteor had been often seen. The valley cuts deeply into compact loam, and is marshy at its lower part. The water of the marsh contains iron, and is covered with a shining crust. During the day bubbles of gas were seen rising from it, and at night bluish-purple flames were observed playing over the surface. On visiting the spot by night, the sensitive flames retired as the major advanced; but on standing quite still, they returned, and he tried to light a piece of paper at them, but the current of air produced by his breath kept them at too great a distance. On turning away his head, and screening his breath, he succeeded in setting fire to the paper. He was also able to extinguish the flame by driving it before him to a part of the ground where no gas was produced; then applying a flame to the place whence the gas bubbles issued, a kind of explosion was heard over eight or nine square feet of the marsh; a red light was seen, which faded to a blue flame about three feet high, and this continued to burn with an unsteady motion. As the morning dawned the flames became pale, and seemed to approach nearer and nearer to the earth, until at last they faded from sight. The same observer also made experiments in other places. At Malapane, in Upper Silesia, he passed several nights in a forest where the meteor was to be seen. In the Komski forest, in Poland, the flame appeared of a darker hue than usual, and on attempting to ignite paper and shavings of wood they became covered with a viscous kind of moisture, as in Musschenbroek's observation, when an *ignis fatuus* was "catched." On another occasion he succeeded in lighting up the meteor by standing at a distance and hurling ignited fireworks into the marshy ground. He visited by night the summit of the Porte Westphalia, near Minden; the meteor was not visible, but on firing a rocket into the marsh a number of small red flames were observed, which soon went out, but appeared again on firing another rocket.

Hence, it will be seen that the *ignis fatuus*, or "will-o'-the-wisp" or "jack-o'-lantern," is due to the ignition of a gas arising from the decay of vegetable matter, and known as marsh-gas, or light carburetted hydrogen. Low-lying meteors due to phosphorus and electricity will be treated of in another article.

Letters.

[The Editor does not hold himself responsible for the opinions or statements of correspondents.]

To the Editor of Knowledge.

Dear Sir,—May I suggest to the writer of "The Astronomy of Shakspeare" in Knowledge, that the seven stars referred to when Falstaff says, "Indeed, you come near me now, Hal: for we that take purses, go by the moon and seven stars, and not by Phœbus," are the seven stars forming Charles' Wain?—for this constellation, after the moon, forms the most conspicuous object of the night sky. Believe me, yours sincerely,

Harold M. Collison.

Hillsboro', Wallington, February 2nd, 1893.

[Mr. Collison is probably right, for in Shakspeare's time it was necessary to count in the sun and moon to make up the seven planets. Falstaff probably did not refer to the seven stars of the Pleiades, but to the better known seven conspicuous stars of the Great Bear, which pointed out the north and indicated the time to the intelligent traveller. A friend reminds me that the Latin and French word for north, *septentrionale*, is derived from these seven stars, and that the Great Bear is still commonly referred to in Italy as the seven stars.—A. C. Ranyard.]

THEORY OF THE SUN.

To the Editor of Knowledge.

Sir,—I hope you will allow me to answer briefly the objections enumerated in the last number of your magazine against my explanation of the prominences as *merely evanescent illuminations caused by the propagation of chemical action in comparatively tranquil matter*. . . . . .

Miss Clerke states "that the rate of propagation of chemical action is, so far as terrestrial experience goes, exceedingly slow as compared with the enormous velocities testified to by line-displacements in prominences." That objection would be fatal if even the least analogy could be expected between the propagation of chemical action in the hot solar atmosphere and such a propagation in the ignited

explosive mixtures tested in our laboratories. But there is here no necessary analogy. In the explosive mixtures of our laboratories the propagation of chemical action is relatively slow, because each successive part of the mixture must needs be ignited and exploded by the heat evolved before the action can pass onward. In the explosive mixtures of the solar atmosphere such a heating cannot take place. *Chemical action is not caused there by a considerable heating, but by an almost infinitesimal cooling.* The cooling required is almost infinitesimal because the rate of dissociation of solar matter necessarily corresponds with the temperature. The cooling required will occur, and cross the solar atmosphere from the bottom to the top with the velocity of radiant heat, when the heat radiated by the photosphere is suddenly diminished by the forming of a spot or pore. If that sudden cause of cooling is not immediately attended by chemical action propagated also with the velocity of radiant heat, it is because the dissociated matter is not always ready to combine on the least loss of heat.

Another objection is "that the rapid translation towards or from the eye of the luminous condition in gases should give rise to greatly widened lines, unless the kindling action was instantaneously followed by extinction." Here I must remark that the prominence lines are sometimes greatly widened, and that in the cases where displacement is observed without widening there is no great difficulty in conceiving that the kindling is instantaneously followed by extinction. . . . . .

The last objection of Miss Clerke is that *the forms of many prominences* seem to indicate real movements of matter; but I think that such indications must be accepted with caution. The cirri-clouds of our own atmosphere, for instance, seem also very often to be formed by real movements of their cloudy constituents. *But that appearance is surely misleading* when it is shown by cirri suddenly appearing, and then covering *almost instantaneously* a great part of the heavens with their straight or elegantly curved, parallel or divergent filaments. Many prominences have, moreover, very capricious and frequently broken forms, which show often-changing entirely discordant directions when suddenly appearing in the higher layers of the solar atmosphere, running in different directions with irregularly varying and *speedily increasing* velocities. They do not, to my mind, convey any idea of actual motion in a *resisting* medium. If the prominences, as we see them, consist of several prominences superposed on one another, the difficulty of explaining their sudden outbreaks in the higher layers of the solar atmosphere by the hypothesis of upward projection increases; for if it is difficult to assume that one prominence should have its connecting stem with the underlying photosphere hidden by some cool mass, the difficulty is increased when there are several co-existing prominences.

Your last objection is that solar observations "do not seem to point to an undisturbed stratification of the solar atmosphere in which the heavier gaseous compounds sink to the bottom." According to you the matter in the solar atmosphere is well churned and evenly mixed, and its different spectra at different levels are caused by differences of temperature. Your explanation, however, does not explain why the matter indicated by the spectroscope in the lower regions is generally much *heavier* than the matter above. There is no reason why metals should require a higher temperature to show lines than hydrogen. It seems also to me very difficult to comprehend that in the close neighbourhood of the *immense* photosphere the temperature should be so low that iron vapour would not show its lines, for we know that even in the Bessemer flame those lines are easily detected, and that they have also been observed in the immensely rarefied matter of comets when heated in the proximity of the sun. . . . . .

Yours faithfully,

Dr. A. Brester, Jz.

Delft, Holland, February 16th, 1893.

[I have printed the parts of Dr. Brester's reply which seemed to me most cogent. His first point seems to amount to the statement that we know nothing about the chemistry of hot bodies, and therefore explosions on the sun *may* be propagated with the velocities which his theory requires. They are certainly not propagated in the sun with the velocity of radiant heat, and if it were possible that a spot or pore in the photosphere could throw a shadow, as Dr. Brester suggests, the cooling effect would be produced in radial lines from the sun, and not in the curiously contorted forms which the prominences present. On the one hand we have vague guesses at what the velocity of explosions with an unknown chemistry might be, and on the other we have the fact that the observed upward velocity of several of the great projection prominences has been shown to correspond with the velocity of matter projected upwards under the influence of solar gravity in a thin resisting medium.

How Dr. Brester reconciles his theory of explosions with a quiescent solar atmosphere I do not understand, for explosions seem to me to imply disturbance and the actual displacement of matter, so that if there were no such thing as gaseous diffusion the vaporous material of the sun would be speedily mixed. The spectra of terrestrial elements which can be recognized in the sun are not arranged vertically in the order of their vapour density, and we know that in the spectra of metals in the electric arc some lines are longer than others, that is, some of the lines are only visible in the hot central region of the arc, while others extend into the cooler outer region.—A. C. Ranyard.]

THE LIFE OF STARS.

To the Editor of Knowledge.

Sir,—I am not aware that the theorists who have written on the evolution of stars have hitherto attempted to trace out the effects of the supposed changes on the stellar spectra. I venture to offer a few suggestions on this topic.

Starting with the nebular theory, some form of which seems to be generally accepted, we would have a bright-line spectrum to commence with. If the nebula was distant and had shrunk to small dimensions it might be otherwise undistinguishable from a star. The continuous spectrum would not appear until condensation (probably into the liquid form) had commenced. But this might commence in two ways—the formation of a central solid (or rather liquid) nucleus and the formation of luminous clouds. The sun's photosphere probably is of the latter character. The solar spots seem to be breaks in the clouds, revealing glimpses either of a solid nucleus or of a second cloud-bank below. But these breaks are caused by disturbances which somewhat complicate the phenomena.

The light of a central nucleus would reach us through a great depth of absorbing gases. The dark lines would therefore in all probability be numerous and strongly marked; but bright lines might, I think, also be expected to appear. The hemisphere of the star turned towards us would consist of a solid portion seen through the gases, and another portion (and at early stages a much larger one) purely gaseous. The gas-light would thus come to

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us from a much greater surface than the continuous light, and might make up in quantity what it wanted in intensity. Such a star would not, I think, be variable in the ordinary sense, but as time rolled on the continuous spectrum would become more powerful, the bright gas-lines would die out, and the dark absorption lines would become less numerous and less marked. The radius of the nucleus would become more nearly equal to that of the star, and the depth of the absorbing atmosphere would slowly diminish.

Cloud formations would produce different phenomena, for clouds could not be expected to remain constant, but to form, dissipate, and reform, though slowly increasing on the whole. They would probably not form at the outer surface of the nebula (since only the lighter and finer gases, such as hydrogen, would be found there), but at some depth below. Absorption-lines, particularly of the lighter gases, might therefore be expected, though not so numerous or so well marked as when the light came from a central nucleus. Bright lines would probably appear at the earlier stages also, for the clouds would not cover the entire surface. The rotation of the star on its axis would probably produce variations of a periodic kind, for it is not likely that the clouds would be equally developed on both hemispheres of the star until they had formed to such an extent as to cover almost the entire surface. Gradually the variations would cease and bright lines die out, the entire surface becoming clouded over.

These deductions partly agree with and partly differ from the results of observation. Stars presenting the phenomena indicative of a central nucleus seem more inclined to variation than those whose phenomena are suggestive of clouds. Perhaps, instead of a central nucleus, clouds are formed at a great depth in such cases. Again, in the cloud-stars the bright lines should be most conspicuous when there is least cloud, *i.e.*, at the minimum, but they seem to be most conspicuous at the maximum. Of this I see no satisfactory explanation. An outburst of highly-heated gases through a break in the cloud might perhaps produce this effect, but if sunspots are of this character they are always darker than the surrounding portion of the surface. Messrs. Carrington and Hodgson, however, observed a phenomenon of a different kind on one well-known occasion. Truly yours,

W. H. S. Monck.

THE η ARGÛS REGION OF THE MILKY WAY.

By A. C. Ranyard.

We are indebted to Mr. H. C. Russell, Director of the Sydney Observatory, New South Wales, for the two photographs given in this month's number of Knowledge. They represent, on different scales, the remarkable region of the southern Milky Way around the variable star η Argûs. At first sight it is not easy to compare them or to recognize what part of the one picture is represented on a larger scale in the other.

The left-hand picture was taken with a short focused instrument, which threw an intensely bright but small image on the plate, while the right-hand picture was taken with a 13-inch refracting telescope of about eleven feet focal length, used at the Sydney Observatory for the international photographic survey of the heavens. The image thrown by it upon the sensitive plate was larger and fainter, but more sharply defined, than the image thrown by the smaller instrument, consequently the right-hand picture does not show the fainter outlying parts of the nebula, which are shown in the other picture, but it shows the nebulous structure on a larger scale. In fact the whole region shown in the right-hand picture is comprised within an area of about two inches by three, near to the centre of the left-hand plate.

This region of the Milky Way shows some dark channels and dark structures, which are such striking features when seen in the telescope that they attracted the attention of Sir John Herschel, and are minutely described by him in the "Cape Observations." He also recognized the connection between the dark regions and the lines of stars which border them. The facts disclosed point to such important conclusions that I propose to reproduce Sir John Herschel's drawing in another number of Knowledge, together with an additional large photograph of this region, and will postpone any remarks with regard to the dark structures till all the photographs are before my readers for comparison.

In the meantime those who are interested in the subject will find a photograph on a small scale of the η Argûs region and surrounding clusters in the June number of Knowledge for 1891. It shows the exceptional character of this region of the Milky Way. As Herschel remarked, it is coarser grained than other parts of the galaxy, and is rich in loosely-packed clusters of stars. The η Argûs nebula is a star cluster as well as a nebula, and the question, What is a nebula? seems to be intimately associated with the equally difficult question, What is a star cluster?

The variable star η Argûs, which gives its name to this nebulous cluster, is a reddish star now too small to be visible to the naked eye. It is immersed in the nebulosity on the following side of the dark structure, or hole in the nebula, which Herschel named the "key-hole," though it looks very little like a key-hole in these photographs. η Argûs is in the upper or northern nebulous mass surrounded by a number of smaller stars. It was first observed by Halley, at St. Helena, in 1677, and was rated by him as of the 4th magnitude. According to Winnecke, it was next seen by Père Noël, a Jesuit missionary, in China, about ten years later, who rated it as a 2nd magnitude star, as it also appeared to Lacaille sixty-four years later, in 1751. Sir John Herschel mentions that in the subsequent catalogues of Fallows (1822), Brisbane (1826), Johnson (1832), and Taylor, it was ranked as a star of the 2nd magnitude, but that it was observed in February, 1827, by Mr. W. J. Burchell, at San Paulo, in Brazil, to be as brilliant as α Crucis. Another vigorous outburst of its light was observed by Sir John Herschel at the Cape, on the 16th December, 1837. It suddenly increased from the 2nd magnitude and became as bright as Rigel. It continued to increase in brightness till the 2nd of January, 1838, when it was as bright as α Centauri. It then declined in brightness and again increased, then decreased and increased again, till, in April, 1843, Sirius alone amongst the fixed stars slightly outshone it. This intense brightness was maintained for some ten years, when it was observed by Gilliss at Santiago in 1850 as very little inferior to Canopus in light, and in colour to be more deeply tinged with red than Mars. According to Miss Clerke, who gives a curve representing its changes of brightness (see her *System of the Stars*, p. 118), it was still of the first magnitude in 1856, it fell to the second in 1858, to the third in 1859, and ceased to be visible to the naked eye in 1868. Twenty years later its magnitude was rated by Mr. Finlay at the Cape as 7·6. Since that time it has slightly increased in brightness, and its tint has changed from "dull scarlet" to "bright orange." Evidently changes are still going on; the observations seem to indicate that it is an irregular variable, rather than a star having a regular period of change.

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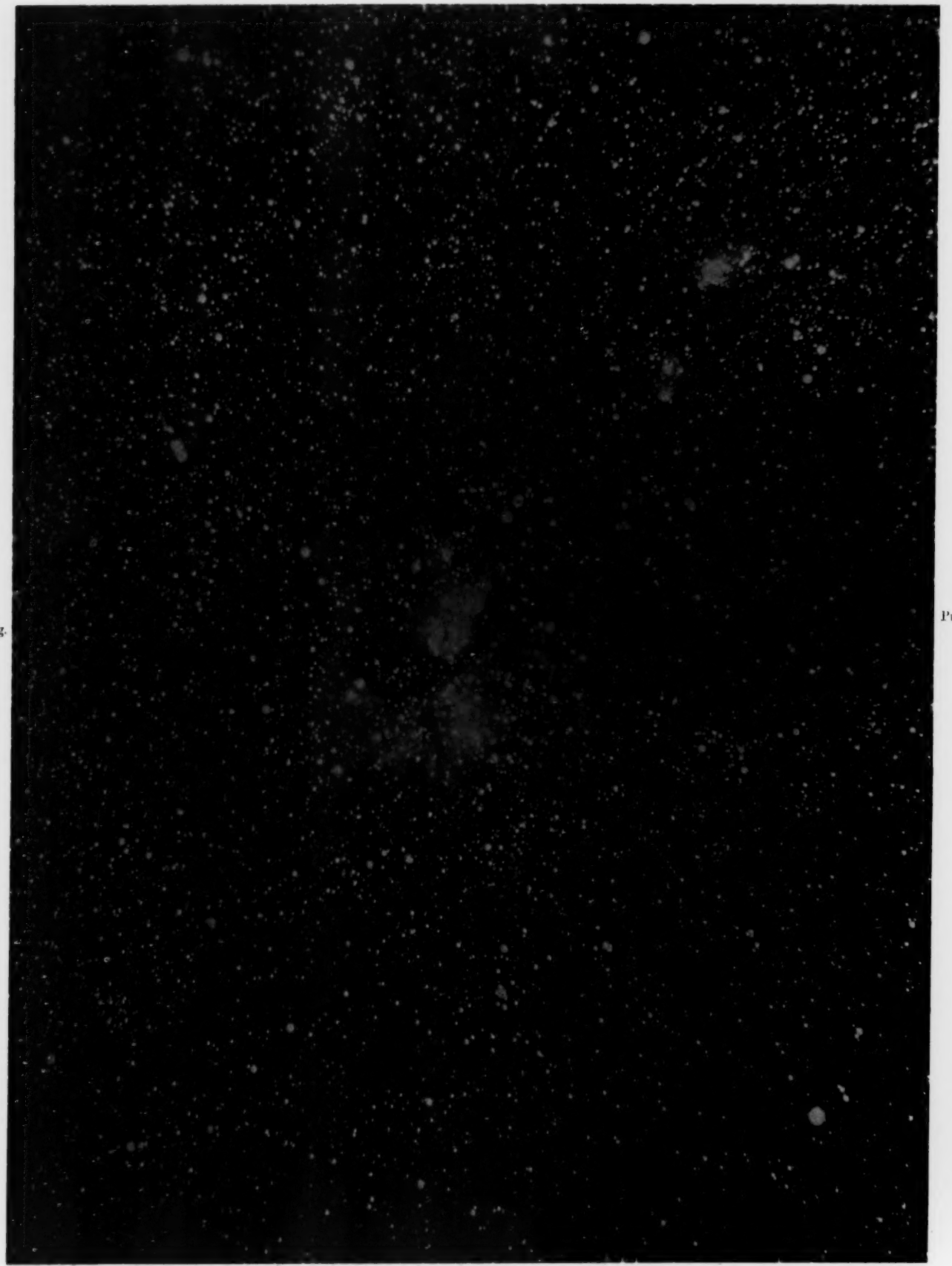

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THE η ARGÛS REGION OF THE MILKY WAY.

From a photograph taken by Mr. H. C. RUSSELL, Director of the Sydney Observatory, with a portrait lens by Dallmeyer of 6 inches aperture and 32 inches focus, and an exposure of 8 hours. Scale of the Original 0·558 in. = 1°. The scale of this Enlargement is approximately 1·8 in. = 1°.

Direct Photo Engraving Company, 9, Barnsbury Park.

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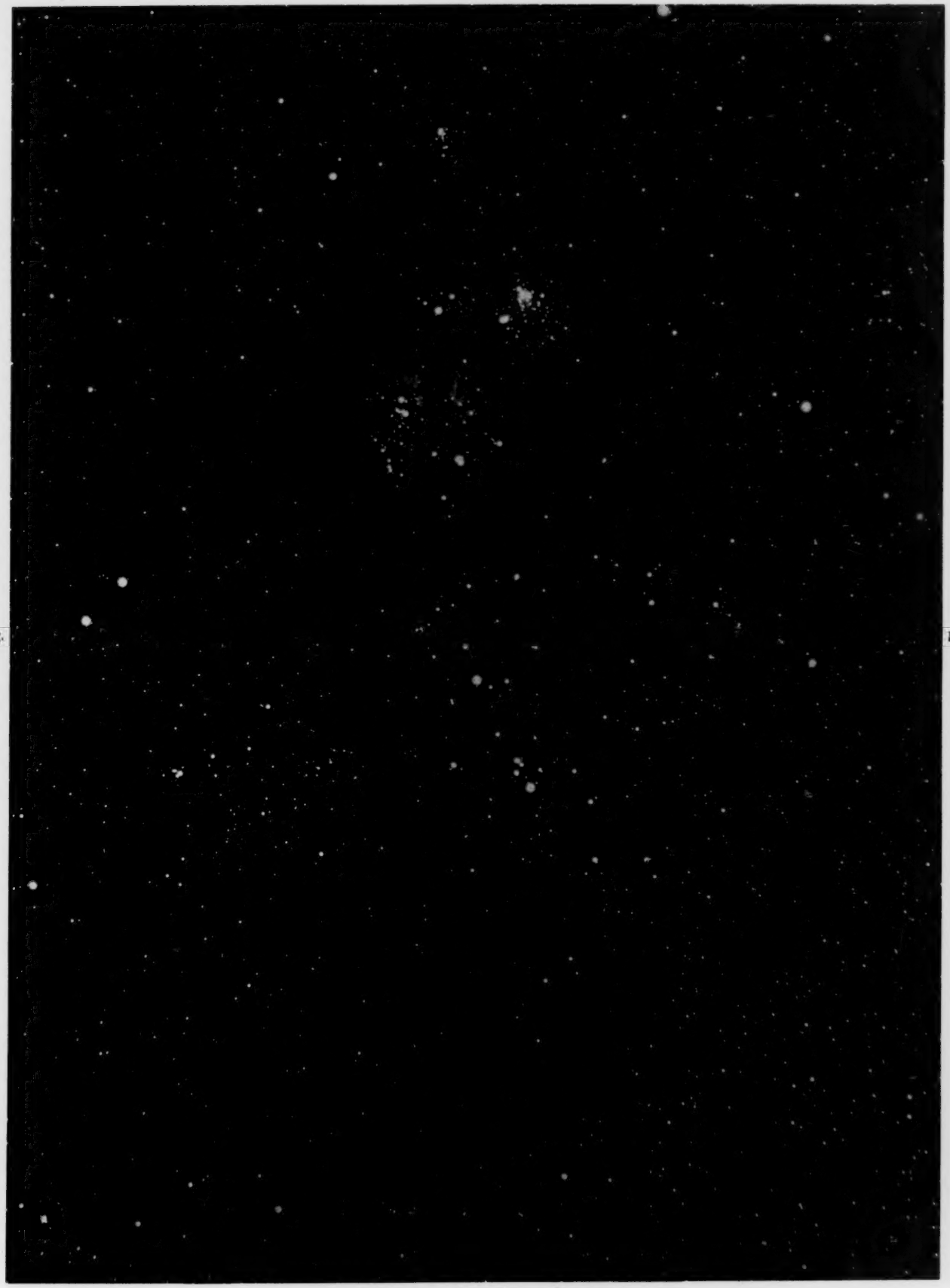
NORTH.



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PHOTOGRAPH OF THE η ARGÛS NEBULA.

Taken by Mr. H. C. Russell, with the Astro-Photo-telescope of 13 inches aperture used for the International Survey of the Heavens. Scale of this Enlargement $6\frac{3}{4}$ in. = 1°. Exposure, 8 hours.

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Notices of Books.

Familiar Studies in Homer. By Agnes E. Clerke (Longmans, Green & Co.). Miss Clerke, who is well known to our readers by her astronomical writings, treats in this delightful book of many details of life and civilization during Homeric times. The volume is a collection of essays or articles, many of which have been already published in the pages of *Nature*, *Macmillan*, and the *British Quarterly Review*. In discussing the Homeric knowledge of astronomy Miss Clerke points out that none of the planets are referred to in either the Iliad or the Odyssey, though many of the fixed stars and constellations are described and named, a fact which points to the high antiquity of the Homeric poems. Hesiod, she remarks, appears equally unconscious, with Homer, of the distinction between the "fixed" and "wandering" stars. In another chapter Miss Clerke deals with "Homeric Horses," "The Dog in Homer," "The Metals in Homer." A very interesting chapter is that on Homeric meals. The Homeric bill of fare was concise and admitted of slight diversification. Day after day, says Miss Clerke, and at meal after meal, roast meat, bread, and wine were set before perennially eager guests, in whose esteem any fundamental change in the materials of the banquet would certainly have been for the worse. Variety, in fact, was in the inverse ratio of abundance; butcher's meat (as we call it) was the staple food of Greek heroes. Oxen, however, were not recklessly slaughtered; "great meals of beef" usually honoured great occasions. The fat beasts, reckoned to be in their prime at five years old, met their fate for the most part in connection with some expiatory ceremony, as that employed to stay the pestilence in the First Iliad. The gods were served first with tit-bits wrapped in fat and reduced by fire to ashes with steamy odours, supposed to be peculiarly grateful to immortal nostrils. Vegetables figured very scantily, if at all, at Achæan feasts; one species only is expressly apportioned for heroic consumption. Nestor and Machaon were guilty of eating onions as a relish with wine. Wine was also mixed with goat's cheese and honey, and esteemed the most refreshing and delightful of drinks. The book is interesting from beginning to end, and can be heartily recommended.

Astronomy for Every-day Readers. By B. J. Hopkins (London: Geo. Philip and Son, 1893). This well-illustrated little book explains in a simple and very elementary manner the phenomena of the tides, the seasons, eclipses and occultations, meteors, shooting stars, and comets. The chapter on the phenomena of meteors is especially interesting, as Mr. Hopkins is himself a practical observer of meteors. At page 78 he gives a good picture of the corona visible in Egypt during the eclipse of 1882, but it is turned the wrong way up, and the comet which was shown on the eclipse photographs at a distance of about a radius from the sun's limb has been tampered with by the artist and turned round so that its tail, in the neighbourhood of the nucleus, is directed nearly radially towards the sun's centre, as is usually the case with comets, but in this instance it was inclined at a considerable angle to the radius vector. As this cannot be an effect due to perspective, it probably indicates that the comet, when near to perihelion, was moving very rapidly compared with the velocity with which the matter of its tail was being driven backward from its nucleus.

Remarkable Comets. By William Thynne Lynn (Edward Stanford, 1893). Mr. Lynn's gift for historical research is already well known. In this little book of forty pages he brings together a mass of historical information with respect to the more remarkable periodical comets, which will be found generally interesting as well as valuable to the student. Mr. Lynn barely attempts to deal with the physical constitution of comets, but some of his remarks are original and bold. Speaking of the observed connection between some comets and meteor streams, he says "It is quite possible that the observed identity of orbits, instead of showing community of composition, simply arises from the comet having been caught and kept in durance by the meteors. The small mass of comets is evidenced by the absolutely imperceptible effect produced in altering the motions of the planets and their satellites when comets have approached them." Thus Lexell's comet is instanced as having passed nearer to Jupiter than its most distant satellite, without having produced any recognizable change in the orbit of the planet or its satellites, though the orbit of the comet was entirely changed by the *rencontre*.

Science Notes.

Prof. C. A. Young, in a recent letter, states that he sees the fifth satellite of Jupiter with the Princeton 23-inch achromatic whenever circumstances are favourable at the time of elongation. He makes the period 11h. 57m. 4s.

Two parties are leaving England to make observations during the solar eclipse of April 15th—16th. One will be stationed at Para Cura, in Brazil; the other, about sixty miles from Bathurst, on the West Coast of Africa. The sun will be totally eclipsed for 4 mins. 43 secs. at the former station, and 4 mins. 12 secs. at the latter.

An electric locomotive of about 2000 horse power, or more than the power of the largest steam locomotive, is reported as finished at Baden Zurich.

In the January number of the *American Journal of Science*, Mr. Clarence King has a paper on "The Age of the Earth," in which he has applied some recent work in geological physics to Lord Kelvin's reasoning as to the probable rate at which the earth has cooled, and by this means he arrives at the value of twenty-four million years for the earth's age.

It has recently been decided in the American Supreme Court that a meteorite, though a stone fallen from heaven, belongs to the owner of the freehold interest in the land on which it falls, and not to the tenant.

Wiedemann's Annalen contains an account of a number of experiments made by Mr. Wesendonck to determine whether electricity is produced by the friction of gases. The results show that no electrification is produced by the friction of pure gases, or of air freed from dust and moisture, but only when solid or liquid particles are suspended in them.

It has recently been shown in Germany that light exercises a deleterious action upon certain micro-organisms, so that the natural purification of sewage matter in rivers during their flow must be partly due to sunlight. Another investigator has found that red rays favoured the growth of certain bacteria, whilst violet rays acted prejudicially—although less so than the white rays.

It is well known that extreme cold paralyzes every vital function, but Prof. Pictet has discovered that at a temperature of -150° C. no chemical action takes place between nitric or sulphuric acid and potash, or between oxygen and potassium, though, under ordinary circumstances, so great is the affinity of the latter metal for oxygen that it will burn if thrown into water, owing to its combination with the oxygen in that fluid.

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Prof. Crookes and others have for some years been making experiments which go to prove that the so-called elements have not the absolutely fixed atomic weights generally assigned to them, or that there exist a great number of unrecognized substances shading off by almost imperceptible differences from one element towards another. The latest experiment is that of Lord Rayleigh, who has prepared nitrogen by two different methods, and finds the atomic weight of one specimen to be one-thousandth part less than that of the other.

By the reflecting power of a surface is meant the ratio of the amount of light reflected by it to the total amount of light incident upon it. Zöllner and others have determined this ratio for various substances, and also for the planets and some of their satellites. Dr. Sumpner has recently made a number of similar measures of the reflecting powers of common materials. He finds that white blotting paper reflects 82 per cent. of the incident light; white cartridge paper, 80 per cent.; tracing cloth, 35 per cent.; ordinary foolscap, 70 per cent.; deep chocolate paper, 4 per cent.; and black velvet, only 0·4 per cent.

We are glad to notice (says *Natural Science*) that the New Zealand Government is actively engaged in preventing the total extinction of the rarer plants and animals of the colony. Acting on the advice of Mr. Henry Wright, the Government has arranged for the purchase of Little Barrier, or Hauturu Island, near Auckland, which will be kept as a national preserve. This island measures 4½ miles in length by 3½ miles in breadth, and rises in the centre to an elevation of 2000 feet. It is generally rugged, but there is comparatively flat land at the northern and southern extremities. Even now its flora and fauna are particularly rich and varied, and no more suitable area could have been secured.

The illustration of scientific lectures or papers by means of lantern slides is becoming fairly general, and it certainly tends to render the meetings of learned societies more instructive as well as more interesting. In this way the physical features of a country, or the microscopic structure of a rock, the organisms of sewage, or the "extinct monsters" of many geological periods, may be reproduced on the screen from photographs or original drawings. The Astronomical Society, the Royal Society, the Linnæan Society, the Royal and the London Institutions, the Geologists' Association, and probably other bodies in London, have introduced the lantern into their meeting rooms with marked success; the Geological Society, however, has hitherto held aloof.

It has been asserted that anomalous disturbances of magnetic needles have occurred when brilliant faculæ were visible near the middle of the sun's disc; and the conclusion jumped at was that the two phenomena were intimately connected. In the *Comptes Rendus* of February 6th, Prof. George Hale deals with this theory. Photographs of the sun have been taken with the spectro-heliograph of Kenwood Observatory since the beginning of last year. Of the 142 pictures obtained, 132 show one or more groups of faculæ on or near the central meridian of the solar disc. It would therefore have been difficult to find an unusual movement of the magnetic needle which did *not* coincide with the appearance of faculæ near to the middle of the sun's disc.

The engineer of the Channel Tunnel Company makes the following statement in his recent report of the trial boring for coal—"The coal boring has now reached a depth of 2228 feet, including 1071 feet of coal measures in which nine workable seams have been found, containing altogether 20 feet in thickness of good bituminous coal. This coal is suitable for gas making and household purposes. The deepest seam, 4 feet in thickness, was met with at 2222 feet from the surface."

A series of very interesting photographs has been made illustrating the movements of the growing parts of such climbing plants as the convolvulus and the hop plant. It is said that the "movement of the young stems consists of a succession of irregular circular or elliptical curves which vary every moment, even in their direction." This successive series of photographic records reveals some interesting facts. For instance, it is found that, even when they are asleep, plants move continuously, and not intermittently, as was formerly supposed.

Mr. Edmund G. Gardner, of Cambridge, contributes to *Nature* (Jan. 26th) a most interesting article on Dante's "Inquiry concerning Water and Land." The treatise is little known in comparison with the other writings of the poet, but its genuineness and importance are now almost universally admitted. It seems to have been his last work, and has not yet been translated into English. According to this work, a good deal of so-called *modern* science was anticipated by the great Italian poet. Mr. Gardner concludes by giving a list of nine scientific truths about the earth known to Dante, amongst which are (1) the moon, the principal cause of tides; (2) equality of the sea's level; (3) "centripetal force"; (4) sphericity of the earth; (5) northern grouping of the continents; (6) universal attraction; (7) elasticity of vapours as a motive power. The reader is referred to Signor A. Stopani ("La questione dell' Acqua e della Terra di Dante Alighieri," in "Opp. Lat. di Dante," ed Guiliani, Vol. II.).

A large audience assembled at the Royal Institution on February 21st, to hear Prof. Dewar lecture on "Liquid Air." Until recently, liquid oxygen was a curiosity, only produced in very small quantities—too small and too evanescent to admit of any exact examination of its properties. Prof. Dewar produces it by the pint, and demonstrated its more obvious physical properties—its beautiful blue colour, somewhat like the blue of the sky, its high magnetic quality, and its characteristic spectrum—with as much facility as if he had been dealing with water. He surrounds the vessel containing the liquid with a high vacuum, in order to reduce the flow of heat, by convection, not by radiation, as was suggested in the *Times*. Liquid air behaves in the magnetic field and in the spectroscope simply as diluted oxygen. When the liquid is allowed to boil, the nitrogen distils off first (having a lower boiling point), and the oxygen follows.

Dr. Gilbert, of the U.S. Geological Survey, communicated a quaint paper on the origin of lunar craters to the National Academy of Science, in November, 1892. His theory is based upon the phenomena of the planet Saturn and its ring. "Assume," says Dr. Gilbert, "that a similar ring of minute satellites once encircled the earth, and that these gradually became aggregated into a smaller number of larger satellites, and eventually into a single satellite—the moon. The craters mark the spots where the last of the small bodies collided with the surface,

when they finally lost their independence and joined the larger body." According to Dr. Gilbert's theory the moon would have been most bombarded in its equatorial regions. But there are very numerous craters in the neighbourhood of the lunar poles; indeed, the polar regions seem to have been more disturbed by what is usually spoken of as volcanic action than the lunar equatorial regions. On the side of the moon turned towards us the planes seem to be aggregated towards a zone which is not greatly inclined to the plane of the lunar orbit.

A novel idea was brought out by Mr. Francis Galton in a lecture delivered at the Royal Institution on January 17th. It consists in expressing outline drawings by means of letters or numbers. Anyone can understand that sketches of a face, or an outline map, can be reproduced by arranging a number of small discs or counters so as to imitate the alignment of figures and that any figure could be constructed, step by step, if the bearing of each disc, with respect to the one before it, is known. Suppose each of the sixteen principal points of the compass is represented by a separate letter of the alphabet, and it were desired to translate a map of England into a formula on Mr. Galton's plan. The outline would be imitated by laying down a series of small discs on a flat surface. Then, beginning, say from Land's End, the bearing of such disc with respect to the preceding one would be observed, and the letter which distinguishes the bearing, would be written down. When this has been done for the entire map, a string of letters is obtained as its formula. The map could afterwards be reconstructed from this formula at any place by laying down discs or points in the manner indicated by the letters. The utility of translating a drawing into a formula, and then reconstructing the same drawing from it, is not obvious at first sight; but when it is remembered that such a formula could be transmitted by telegraph, the importance of the plan becomes apparent. The site of a battle, the plan of a newly-explored region, a design, or even a portrait, could be wired as easily as any other information, and the cost need not be great. Mr. Galton exhibited a map of England at the lecture made with 248 dots, and its cost of transmission from the United States would only be about £5, which is small in comparison with the amounts spent by newspapers on telegraphic information. It seems very probable, therefore, that pictorial telegraphy "may have a future."

THE CONSTITUTION OF GASES.

By J. J. Stewart, *of Emmanuel College, Cambridge.*

WITHIN comparatively recent years, it was generally taught that the pressure exerted by a gas on the sides of the vessel which contained it was due to a mutual repulsion of the particles of the gas. Now, the beautiful kinetic theory of gases furnishes us with a much more satisfactory and withal more simple explanation of the behaviour of gases. While this hypothesis, in its main features, is simple, and easily understood, to advance any distance into its method and results requires considerable mathematical knowledge. Still, as the statement of the principal laws of matter in the gaseous state, in accordance with the kinetic theory, can be readily made and grasped, I propose to endeavour shortly to give the results hitherto arrived at by scientific men working in this department of physics, together perhaps with some of their methods of investigation, so far as the latter can be done without the aid of mathematical symbols.

The anticipations of modern discovery which were made by some of the keener intellects, among the ancient Greeks especially, is most remarkable. The idea that many of the observed properties of bodies around us, which are apparently at rest, are due to the particles composing these bodies being in reality in a state of rapid motion amongst themselves, is to be found distinctly stated by the Roman writer Lucretius. His conception of atoms "strong in solid singleness" comes surprisingly near to some modern hypotheses as to the constitution of matter.

The atomic theory of matter was expounded by Democritus of Abdera, in Thrace, and the interest felt at that time, *i.e.*, about 450 B.C., in such questions is shown by the fact that the lecturer realized a handsome sum in talents of gold.

Anaxagoras, known as the teacher of Socrates, stated a theory which was diametrically opposed to that of Democritus. According to his speculations, matter is infinitely divisible; the smallest divided portions can again be divided, and this without end. Thus he considered matter to be homogeneous, to have the same structure throughout, and that there was no limit to the smallness of the possible particles.

On the other hand, Democritus taught that matter is not infinitely divisible, but that if we could continually divide up portions of matter we would at length reach particles which could no further be divided, *i.e. atoms*—things which cannot be cut. In this belief Democritus was followed by Epicurus and Lucretius, and it is to a very similar idea that modern research has been led. But the present views of physicists are founded on the method of questioning Nature by experiment, and reasoning on the results found in answer to their enquiries. These ancient philosophers spun their more or less ingenious theories out of *à priori* notions in their own minds.

Daniel Bernoulli, the mathematician, born in 1700, was probably the originator of the thought that the pressure exerted by a gas on the walls of its containing vessel is caused by the bombardment of these walls by the minute particles of matter making up the gas. For long after his time no further step was made in discovery, and his remark seems to have remained comparatively unnoticed.

Roughly stated, the kinetic theory of gases may be said to be this: A gas consists of separate particles or molecules of matter at a distance from each other, and of excessive smallness; these are continually flying about in all directions, and in their passage they strike against each other, and also against surrounding bodies. Imagine a volume of gas shut into a glass vessel, then the sides of this vessel are exposed to a continual bombardment from the particles of the gas dashing against them. This bombardment of molecules is so continuous and rapid, and the number of particles which strike against a given portion of the containing walls is so large, that the result is a *pressure* outwards on the vessel caused by the gas, and this being resisted by the rigidity of the glass, an equal and opposite pressure inwards balances the pressure outwards exerted by the gas. Though we can never hope to capture or to see a single molecule, yet many experiments and considerations, converging from different starting-points, prove that something of this sort goes on in all gaseous bodies. Of course the assumption of a hard solid atom is entirely arbitrary, and can only be considered a first approximation to the actual truth; yet many of the properties of matter can be explained on the hypothesis that it is made up of such hard spheres, and thus this conception is a valuable aid to fixing and making definite our views as to the constitution of matter. It also serves to express concisely the results arrived at by experimental

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research; though it must be insisted on that the actual constitution of matter is a yet unpenetrated mystery, and one which some able physicists consider to be quite beyond the powers of man to solve. After Bernoulli's time, Lesage, of Geneva, and Prevost applied the theory to explain various phenomena. Herapath also worked in the same field.

In the year 1848, Dr. Joule, of world-wide fame from his researches on the dynamical theory of heat, explained the pressure of gases as being due to the impact of their molecules, and not only this, but he also calculated the velocity which these particles must have in order to produce the observed pressure. It is, however, to Clausius in Germany, and to Clerk Maxwell in our own country, that we chiefly owe the mathematical development of this subject. These physicists, starting from the mathematical theory of probability, and using a statistical method of investigation, which they applied to companies of molecules, arrived at results which agreed with the test of experiment, and which could be applied to whole aggregates of molecules existing under certain conditions, though the behaviour of a single molecule, considered by itself, might be unknown and untraceable.

All portions of matter, whether in the solid, liquid, or gaseous state, consist of a finite number of very minute parts or molecules. This particle or molecule is not necessarily homogeneous throughout, but from chemical considerations we must suppose it to consist of two or more atoms. These atoms, which together make up the molecule of a substance, may consist of matter of the same kind, or of a different kind. A molecule made up of similar atoms forms a particle of an element, *i.e.*, a body which cannot be split up into two different sorts of matter. A molecule made up of differing atoms forms the smallest portion of a *compound*. A molecule may be defined as the smallest conceivable portion of a substance which can move about freely by itself without its constituent atoms parting company.

In solids the molecules can move with reference to each other, but only with difficulty, and they are never outside the influence of neighbouring molecules. Their excursions from one spot are probably of the nature of vibrations. In the case of liquids the constituent molecules are much more free to move about amongst themselves. The particles of the liquid can slide past each other, and the liquid exhibits mobility—it takes the form of the vessel which contains it. A molecule in a liquid can, in course of time, penetrate to any part of the liquid mass, but its course must be a slow one, as it will continually run against other molecules, and have its path changed.

When we come to consider gases, it is seen that here each molecule leads a more independent existence. In a gas at ordinary temperature and pressure, during the greater part of the path of a molecule it is not in direct contact with its fellows.

As during this "free path" of the molecule it is not acted on by any sensible force, it tends to move onwards in a straight line. Soon, however, it encounters another molecule, and from the collision between the two both the velocity and direction of the moving molecules are altered. Each starts off again in a new and different direction, again in course of time to come into contact with other molecules. The free motion of a molecule takes up considerably more time than the duration of an encounter; but as the density of the gas increases there are more and more gas molecules in a given space, and thus they strike each other more frequently, the length of their undisturbed path diminishes, and at length, if the gas is still further condensed, it becomes a liquid in which no portion of a molecule's course can be called its free path; it never gets beyond the influence of its neighbours.

In an encounter between two molecules, since the force of the impact acts between the two masses, the motion of the common centre of gravity of the two molecules must be the same after the collision as it was before. Also it follows from the principle of the conservation of energy, that the velocity of each molecule relatively to their common centre of gravity continues the same in magnitude but may be changed in direction.

It necessarily follows that the velocities must vary as we pass from molecule to molecule. For even if we could imagine all the molecules to be moving with the same velocity at a given instant this velocity would soon be changed by the successive encounters between the molecules. Some of the constituent particles may have a relatively very high velocity, others may be moving comparatively slowly, while most of them will have various velocities intermediate between the highest and lowest.

If the systems of moving molecules be divided into groups according to the velocity which they may have at the instant considered, a regular progression is observed as to the number of molecules which fall into each separate group. At the same time the motion of a simple molecule, if it were possible to follow it, would be found to be exceedingly changeable and irregular. The behaviour of the groups may be stable but the individual molecules making up these groups are continually changing; a molecule belonging to one group or another, according to its velocity at a given instant, and of course belonging to different groups at different parts of its career. This statistical method of investigation resembles somewhat the method of obtaining average characteristics of classes of the community, these being made up of individuals differing amongst themselves; and the results attained are only true when considered as giving broad characteristic outlines of masses of people. The distribution of the molecules according to the speeds with which they are moving is calculated by the theory of probability, and this distribution is found to be of the same mathematical form as that of the marks made on a target when these are arranged according to their distances from the centre aimed at, always supposing that the shots fired are numerous, and that the riflemen have the same degree of skill.

To compare such systems of moving molecules together, it is desirable to take the mean of the *squares* of all the velocities, for the effect of a blow struck by a projectile depends upon the square of its velocity. This is referred to as the *mean square* of the velocity, and the square root of this mean square is called the "velocity of mean square."

Clerk Maxwell has shown that if two sets of molecules whose mass is different are in motion in the same vessel they will, by continually striking against each other, exchange energy until the average kinetic energy of one molecule of either set is the same.

Let M_1 represent the mass of one molecule of the first kind, and M_2 the mass of a molecule of the second sort, while V_1 and V_2 are equal to their respective velocities, then ultimately we shall have $M_1 V_1^2 = M_2 V_2^2$.

In the case of any mass M, with a velocity V, the *kinetic energy* is equal to $\frac{1}{2} M V^2$. So if we call M the mass of a single molecule, and V its velocity of translation, its average kinetic energy is expressed by $\frac{1}{2} M V^2$. But this is not the only energy which the molecule may possess, for any given molecule (with perhaps one or two exceptions, as that of mercury vapour) is made up of constituent parts, it contains two or more atoms, and these may have relative motions amongst themselves, and besides, the molecule as

a whole may have a motion, of *rotation*. All these secondary kinds of motion, which do not consist of motion of the molecule as a whole from place to place, are considered separately and called the internal energy of the molecule. The determination of its nature and amount is a problem of extreme difficulty, and is yet unsolved, though the ratio of the energy of translation or agitation to the internal energy is in some cases known or guessed at.

(*To be continued.*)

LIVING FOSSILS.

By R. LYDEKKER, B.A.

IN an article entitled "The Oldest Fishes and their Fins," * it was pointed out how that through the discovery of the Australian lung-fish † (*Epiceratodus*), the ancient mesozoic fauna of Europe was brought into much closer connection with that of the present day than had hitherto been supposed to be the case. This, however, is by no means a solitary instance of the discovery in a living condition of forms of life which have been regarded as long extinct; and since the subject of the survival of ancient types in remote corners of the earth or the abysses of the ocean is one of wide interest, we propose to consider it in some detail in the present article. For such survivors from a distant past we venture to suggest the title of "living fossils," seeing that for the most part they have but little in common with the dominant fauna of the greater part of the world; while their alliance with extinct types is of the most intimate kind. It is of course difficult to know where to draw the line in the use of such an arbitrary designation; but we shall endeavour to restrict the term either to types which, although still more or less abundantly represented at the present day, are of extreme antiquity, or to such as are now represented by comparatively few forms, living either in distant parts of the world, or in the ocean depths, but which were abundant in past epochs. Of those coming under the latter category, the majority, as might have been expected, were first made known to science from the evidence of their petrified remains, while their existing relatives were not discovered till later. Whether, however, the extinct or the living types were the first to be discovered, the progress of research has been gradually tending to connect the past more intimately with the present than was originally supposed to have been the case.

Our first examples of "living fossils" will be taken from he mollusca, among which the gastropods, described under the name of *Pleurotomaria*, afford the most striking instance. The shells of this genus, which are frequently very elaborately sculptured, have a general external resemblance to a *Turbo* or a *Trochus*, but are readily distinguished by a deep horizontal slit in the middle of the outer wall of the mouth, from which the genus takes its name. The genus *Pleurotomaria* was originally established in the year 1826 on the evidence of a species from the English lias; and a host of other extinct kinds were subsequently described, ranging from the silurian to the chalk. Till 1855, no one, however, had the least idea that the genus was still existing, but in that year a living specimen was obtained off Mariegalante, which was subsequently sold in London in 1875 for £25. The species to which this first recent specimen belonged was named *P. quoyana*; and three examples of the same form have subsequently been obtained. The next discovery of a *Pleurotomaria* occurred in 1861, when an imperfect specimen of another species (*P. adansonia*) was obtained. A second example of this same species was taken in 1882 near Guadaloupe, and three others are in existence, while a seventh was purchased in 1890 at Tobago by Mr. R. J. S. Guppy. The latter example was a very large shell, measuring just under six inches in height; and it was also distinguished by its striking coloration, being marked by a number of oblique splashes of reddish-orange on a pale flesh-coloured ground. A third species of the genus (*P. beyrichi*), represented of the natural size in our figure, was first obtained from Japanese waters in 1877; and three examples have been subsequently secured. Finally, the fourth and largest living species is only known by a single example, which was recognized in 1879 among a collection of shells at Rotterdam, and is believed to have come from the Moluccas. The height of this fine shell is six and three-quarter inches.

FIG. 1. — Shell of *Pleurotomaria*. (After Dr. H. Woodward.)

It will thus be apparent that only fourteen specimens of living *Pleurotomariæ*, referable to four distinct species, are at present known to zoologists. These molluscs, which are known to inhabit deep water on rocky bottoms, must therefore be extremely rare; although from the nature of their habitat it is probable that not so many specimens are obtained as might otherwise be the case. In the tertiary period, according to Dr. H. Woodward, only eleven species are known, of which two are from the pleistocene, two from the miocene, and seven from the eocene. Directly, however, we reach the cretaceous, the number of species suddenly leaps up to 208, while the total number of secondary and palæozoic species is upwards of 1145. Accordingly, out of a total of 1160 representatives of the genus, only fifteen are of post-cretaceous age, of which only four now exist, and these apparently poorly represented in individuals. Here, then, we have indeed a striking instance of a "living fossil."

The well-known bivalve shells named *Trigonia* afford a scarcely less well-marked case of the persistence of early types. This genus was originally named in 1791, on the evidence of an extinct species, but when fully described by Lamarck in 1804 some few recent living examples had also been obtained. For the benefit of those of our readers who may not be familiar with these molluscs, it may be mentioned that the living *Trigoniæ* are rather small shells, of about an inch and a half in diameter, characterized by their somewhat triangular shape, and the strongly marked transverse ribs, marked with rough tubercles on the outer surface. Internally the shell has a polychroic pearly lustre; while the peculiarly-shaped and striated interlocking hinge, when once seen, can never be mistaken. At the present day the *Trigoniæ* are represented only by some five closely allied species, confined to the Australian seas; while in the tertiary, although more widely distributed, they were likewise rare. In the secondary period, where they range down to the lias, these shells were, however, extremely abundant, and attained far larger dimensions than their existing relatives. Indeed, in the oolites *Trigoniæ* were some of the most common molluscs, whole slabs of rock being sometimes found paved with their handsomely sculptured shells, while all who have visited the Isle of Portland must be familiar with the countless swarms in which casts of their shells occur in the so-called "roach-

* KNOWLEDGE, September, 1892.

† The writer is indebted to Mr. Davidson for pointing out in the January number of this serial, p. 13, that the name "barramunda" is not applicable to the lung-fish alone, but denotes all the big fish of the Australian rivers.

bed" of the quarrymen. The survival of *Trigonia* in the Australian seas alone affords a curious parallel to the persistence of pouched mammals and monotremes on that island-continent, and of the lung-fish in its rivers.

The pearly nautilus, of which there are some three or four species from the warmer seas, is likewise entitled to occupy a place among "living fossils," since this group of cephalopods has existed continuously to the present day, from the epoch of the lower silurian, with a progressive diminution in the number of species. It was long considered that the palæozoic nautili were congeneric with the existing ones, but although this is probably not the case, the whole are so closely allied as to show a most remarkable persistence of type throughout untold ages. Nautili have, indeed, witnessed the incoming and the decline of the whole group of ammonites, so characteristic of the secondary rocks; but the reason of the persistence of the one type and the total extinction of the other type appears entirely beyond our ken.

The most remarkable instance of the persistence of type is, however, afforded by the genus *Lingula* among the brachiopods, or so-called lamp-shells. Lingulas have oblong, flattened, and somewhat nail-like shells, composed partly of horny and partly of calcareous matter, and are attached to foreign substances by a long muscular pedicle passing out between the beaks of the two valves, which are generally of a greenish hue. These molluscs range from the Cambrian—at the very base of the palæozoics—to the present day, without any trace of generic modification, and indeed, with no perceptible change. Moreover, the group seems to be now as well represented in species as ever it was, the total number of living forms being given in the second edition of Woodward's "Mollusca" as sixteen while the total of fossil species at that date was but ninety-one. The lingulas are, therefore, the very oldest animals at present in existence. They are, however, run somewhat close by two other genera of brachiopods respectively known as *Discina* and *Crania*, both of which range from the lower silurian or ordovician epoch to the present day. The parallelism in this respect is not, however, so close as it might at first sight appear, since the lower palæozoic representatives of both the latter genera are subgenerically distinct from their living analogues. While the first of these two genera has some ten living species, the latter possesses but five, and both had a large number of palæozoic representatives.

It is, perhaps, almost superfluous to add that the whole of the brachiopods are a waning group, although the types known as rhynchonellas and terebratulas have been ascertained, of recent years, to be more numerously represented, both as regards species and individuals, than was formerly considered to be the case.

The so-called stone-lilies, or crinoids—near relatives of the familiar star-fish, but attached, in the young condition at least, to the sea-bottom by a jointed stem—likewise constitute a group in which by far the greater number of types are totally extinct, although a few survive to merit the title heading the present article. The stone-lilies are divided into two primary groups, of which one is totally extinct, while the other, which does not extend backwards beyond the secondary period, comprises the few existing representatives of the class. The genus which may be selected as especially worthy of the designation "living fossil," is *Pentacrinus*, so named from the pentagonal form of the discs of the stalk—so familiar to all who have studied the fossils of the British secondary rocks. The pentacrinids were originally named on the evidence of certain species from the British lias, which attained a height of several feet, and flourished in extraordinary profusion on the old sea-bottom, as the reader who cares to pay a visit to the fossil galleries of the Natural History Museum may see for himself. For some time the genus was only known from the secondary rocks, but eventually a minute species (*P. Europæus*) was found living in deep

Fig. 2.—A Living Pentacrinid.

water off the Irish coast; while in 1755 a much larger form (*P. caput-medusæ*) was discovered in the West Indian seas. For a long period these living crinoids were supposed to be of extreme rarity, only a few examples being from time to time procured. With the development of deep-sea dredging it was, however, found that pentacrinids were really abundant in certain localities, and several new species (one of which is represented in the accompanying figure) have been named of late years. Thus in the summer of 1870 the late Dr. Gwyn Jeffreys dredged up quantities in the Atlantic; while in the neighbourhood of the Aru Islands the late Professor Moseley tells us that during the voyage of the *Challenger* more than thirty specimens of *Pentacrinus* were taken at a single haul of the dredge in 500 fathoms of water. Although their pyritized remains, which are so common on the slabs of lias, would have indicated that these crinoids must have been creatures of extreme beauty, no adequate idea of their gracefulness would ever have been obtained had the group not been represented in the living state.

Pentacrinids are, however, by no means the only "living fossils" belonging to this class of animals. For instance, the smaller and simpler *Rhizocrinus* of the Atlantic is a survivor from the eocene; while both this genus and the allied *Bathycrinus*, from depths reaching to 2400 fathoms in the Atlantic, are near relatives of the extinct *Bourgueticrinus* of the chalk. Moreover, all these forms are related to the so-called Pear-encrinites (*Apiocrinus*), so common in the middle jurassic rocks of Europe; while these, again,

lead on to the still earlier lily-encrinites (*Encrinus*) of the trias.

If space permitted there are several other groups of invertebrates which might claim our attention, but we must pass on to the vertebrates. Among the fishes the one which has the greatest claim to the title of a "living fossil" is the aforesaid Australian lung-fish of the rivers of Queensland. As we have mentioned in the article referred to, teeth of fishes allied to the Australian lung-fish have long been known from the secondary rocks, ranging downwards to the trias, and occurring in Europe, India, Africa, and North America. These teeth were, indeed, first described by Agassiz as far back as the year 1838; and the group was believed to be extinct till 1870, when one of the two living forms was discovered. At first, as stated in the same article, it was believed that the latter were generically identical with the fossil, *Ceratodus*, but it has been ascertained recently that there are certain slight differences which justify the separation of the living species as a distinct genus. At present we have no decisive evidence of the existence of these fishes between the upper jurassic of the United States and the pleistocene of Queensland, so that there is a long gap in their history to be filled up, it may be hoped, by future discoveries.

The Australian lung-fish is, however, but one of three nearly allied genera, of which the other two (*Lepidosiren* and *Protopterus*) are each represented by a single species, severally inhabiting the Amazons and the rivers of West Africa. These three widely separated types are, then, the sole living representatives of an extensive order which was once widely distributed over the globe, and has been slowly waning ever since the palæozoic period. The group is one of especial interest, since from some of its extinct representatives it is probable that amphibians, and hence the higher vertebrates, have all been derived.

Of nearly equal interest with the lung-fishes are the bony pikes (*Lepidosteus*) of the rivers of North America and the bichir (*Polypterus*)* of the Upper Nile and the rivers of Western Africa; which, together with another West African form (*Calamoichthys*), are the sole existing representatives of the mail-clad ganoid fishes so abundant during the secondary period. The African forms are at present unknown in the fossil state, but the bony pikes date from the lower eocene, and thus indicate continuity with the extinct secondary types.

Another living fossil among fishes is the well-known Port Jackson shark (*Cestracion*), the last survivor of a genus ranging in the secondary rocks of Europe down to the Kimeridge clay; and also the sole living member of a vast group of sharks characterized by the pavement of crushing teeth with which the mouth is covered. As remarked long since by Dean Buckland, cestracionts sharks lived side by side with trigonias in the old jurassic seas of Europe; and it is not a little remarkable to find the same comradeship still kept up on the distant coasts of Australia.

Quite recently another link connecting the present fauna of Australia with that of secondary Europe has been discovered. For a considerable time a peculiar group of herrings (*Diplomystus*), characterized by having a row of scutes on the back resembling those found in other types on the opposite aspect of the body, have been known from cretaceous and early tertiary rocks, their range including Brazil, Wyoming, the Isle of Wight, and the Lebanon. Till the other day, these doubly-armoured herrings were considered to be totally extinct, but now, lo and behold! they have turned up alive in certain rivers of New South Wales.

* Figured in KNOWLEDGE for September, 1892, p. 173.

Among amphibians, the creature which seems best entitled to be called a "living fossil" is the giant salamander (*Cryptobranchus*) of Japan, since, together with a smaller North American kind, it is the representative of a genus once common in Europe during the middle portion of the tertiary period. Indeed, our first knowledge of the group was derived from a fossil specimen of one of these salamanders from the Continent, described in the year 1726 under the title of *homo diluvii testis*, in the belief that it was a human skeleton!

Passing on to the reptilian class, we have to notice that in the year 1842 the late Sir R. Owen described from the triassic rocks of Shropshire the remains of a small lizard-like reptile (*Rhynchosaurus*), differing from all living forms in the structure of its skull, of which the jaws terminated in a peculiar beak. Eleven years previously the late Dr. Gray had, however, applied the name *Sphenodon* to a then very imperfectly known living reptile from New Zealand; which when fully described by Dr. Günther in 1867 turned out to be very closely related to the triassic *Rhynchosaurus*. Although externally somewhat like a lizard, but with a different kind of skin, the tuatara, as the New Zealand reptile is called, differs entirely in the structure of its shell and skeleton in general from the true lizards, and comes much closer in these respects to crocodiles and tortoises. Subsequent researches have brought to light the existence of the remains of a large number of more or less nearly allied reptiles in the secondary rocks of Europe and other parts of the world. Accordingly the tuatara, although not generically identical with any one of these extinct forms, has every right to be regarded as a "living fossil"; while it enjoys the further distinction of being, with the exception of the lancelet, the only vertebrate animal which can be definitely regarded as the sole living representative of a distinct order.

Since birds have no species with any very great claim to be mentioned here, we pass on to mammals, of which our notice must necessarily be brief. In a previous article,† it has been stated that certain remarkable secondary European and American mammals appear to be related to the egg-laying mammals of Australia and New Guinea; and we may, therefore, assume that the latter, as their structure indicates, are very ancient types, although their direct ancestors have not yet been discovered. The banded anteater (*Myrmecobius*) and the bandicoots (*Perameles*) of Australia seem to be the nearest relatives of another great group of secondary mammals, and are therefore probably some of the oldest types with which we are yet acquainted, although here again their exact genealogy is at present unknown. No other groups of living mammals are yet definitely known to have existed before the tertiary period, and the pedigree of the class in general is consequently brief as compared with that of many of the animals discussed above. The opossums (*Didelphys*) are, however, perhaps those mammals best entitled among the tertiary groups to the appellation of "living fossils," as they have existed without generic modification since the period of the eocene, and have now entirely vanished from their old European haunts to maintain an existence in America, where they are mainly characteristic of the southern half of the continent. Although the insectivores and the lemurs (as mentioned in our article in the January number of KNOWLEDGE) are evidently primitive types, but few of their existing genera date far back in the tertiary period, while in the latter group, not a single existing genus is known before

† KNOWLEDGE, November, 1892, pp. 214, 215.

XUM

the present epoch. None of these mammals properly come, therefore, within the scope of the present article. On the other hand, tapirs and rhinoceroses, as dating from the lower part of the miocene or the upper portion of the eocene period, might be considered to claim notice in our survey, while the same remark would apply to the civets of the genus *Viverra*. Since, however, these mammalian types are comparatively well represented at the present day, they scarcely come under the designation of "living fossils." There is, however, one mammal to which this title is strictly applicable, namely, the water-chevrotain of Western Africa. This genus of mammals was originally made known to science upon the evidence of fossil remains from the pliocene rocks of Darmstadt described under the name of *Dorcatherium* in 1836. Four years later, a living ungulate from West Africa was described as a species of musk-deer (*Moschus*), and the same creature was in 1845 made the type of a new genus, *Hyomoschus*. Subsequently other extinct species of *Dorcatherium* were described from the miocene rocks of Europe and the pliocene of India, and it was eventually proved that the African water-chevrotain belonged to the same genus as these reputedly extinct forms. Hence, the animal in question, as being the sole existing representative of a genus which had formerly a comparatively wide distribution and which was originally described as extinct, has the most indisputable claim to rank as a "living fossil."

THE FACE OF THE SKY FOR MARCH.

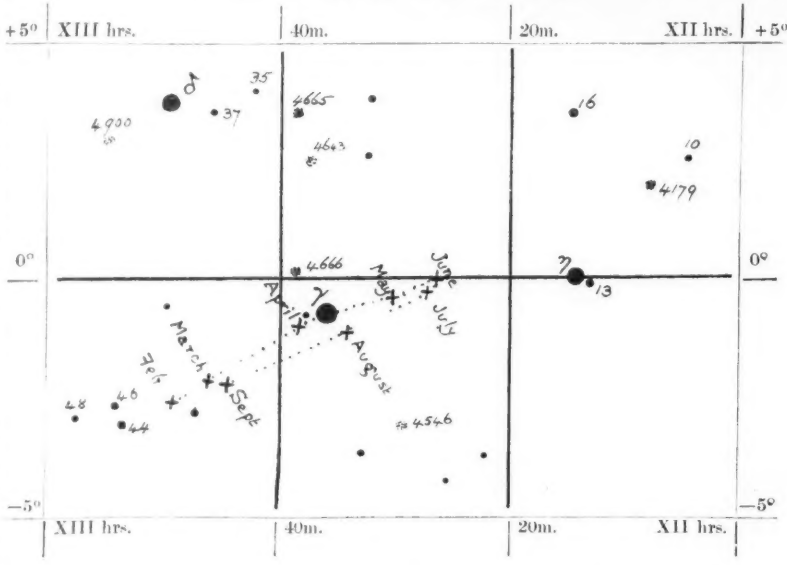
By Herbert Sadler, F.R.A.S.

SEVERAL fine groups of spots have recently appeared on the solar surface. Conveniently observable minima of Algol occur at 0h. 30m. A.M., on the 13th, and at 9h. 19m. P.M. on the 16th. A maximum of the beautiful variable Omicron Ceti will take place about the 11th.

Mercury is an evening star, and is well situated for observation during the greater part of the month, setting on the 1st at 6h. 40m. P.M., or 1h. 2m. after sunset, with a southern declination of 3° 37′, and an apparent diameter of $5\frac{1}{2}''$, $\frac{90}{100}$ths of the disc being illuminated. On the 7th he sets at 7h. 21m. P.M., or 1h. 33m. after the Sun, with a northern declination of 1° 43′, and an apparent diameter of 6″, $\frac{73}{100}$ths of the disc being illuminated, and the planet being then at its brightest. On the 12th he sets at 7h. 47m. P.M., with a northern declination of 5° 37′, and an apparent diameter of $6\frac{3}{4}''$, $\frac{54}{100}$ths of the disc being illuminated. On the 17th he sets at 7h. 56m. P.M., or 1h. 50m. after sunset, with a northern declination of 8° 23′, and an apparent diameter of 8″, $\frac{32}{100}$ths of the disc being illuminated. On the 22nd he sets at 7h. 48m. P.M., or 1h. 34m. after sunset, with a northern declination of 9° 33′, and an apparent diameter of $9\frac{1}{4}$, $\frac{14}{100}$ths of the disc being illuminated. After this he gets too faint and too near the Sun for observation. He is at his greatest eastern elongation ($18\frac{1}{4}$°) on the 14th. While visible he describes a direct path in Pisces, without approaching any bright star. Venus is invisible.

Mars is still visible, but is a very uninteresting object for the amateur. He sets on the 1st at 11h. 29m. P.M., with a northern declination of 16° 10′, and an apparent diameter of $6\frac{1}{2}''$. On the 31st he sets at 11h. 24m. P.M., with a northern declination of 21° 30′, and an apparent diameter of $5\frac{1}{2}''$. During the month he passes through part of Aries into Taurus, being south of the Pleiades on the 25th.

Jupiter is still an evening star, but should be looked for immediately after sunset. On the 1st he sets at 9h. 43m. P.M., with a northern declination of 8° 36′, and an apparent equatorial diameter of 34·6″. On the 31st he sets at 8h. 23m. P.M., or 1h. 53m. after sunset, with a northern declination of 11° 2′, and an apparent equatorial diameter of 32″. He is occulted by the Moon on the morning of the 20th, the disappearance taking place as the planet is rising, at 7h. 1m. A.M., at an angle of 68° from the northern point of the lunar disc, and the reappearance at 7h. 52m. A.M., at an angle of 237° from the northern point. During the month he describes a direct path through Pisces into Aries. On the evening of the 19th a 7th magnitude star will be very closely north of the planet. The following phenomena of the satellites occur while Jupiter is more than 8° above and the Sun 8° below the horizon. On the 3rd an occultation disappearance of the second satellite at 7h. 23m. P.M. On the 5th a transit egress of the shadow of the second satellite at 6h. 50m. P.M. On the 6th a transit ingress of the first satellite at 8h. 23m. P.M. On the 12th a transit ingress of the shadow of the second satellite at 7h. 1m. P.M.; and a transit egress of the satellite at 7h. 55m. P.M. On the 14th an occultation disappearance of the first satellite at 7h. 46m. P.M. On the 15th a transit egress of the first satellite at 7h. 9m. P.M., and of its shadow at 7h. 52m. P.M. On the 22nd a transit ingress of the shadow of the first satellite. On the 23rd an eclipse disappearance of the first satellite at 7h. 4m. 27s. P.M. The following are the times of superior and inferior conjunctions of the fourth



Path of the Planet Saturn in the Constellation Virgo, from February 1st to September 1st, 1893. The map is based on Cottam's Star Chart. γ Virginis (binary) 3·1 magnitude, δ Virginis 3·5, η Virginis 4·0, 16 Virginis 5·5.

satellite:—Superior, March 17th, 11h. 22m. P.M. Inferior, March 9th, 2h. 45m. P.M.; March 26th, 11h. 30m. A.M.

Saturn is well situated for observation, coming into opposition on the 29th at a distance of about 797½ millions of miles. He rises on the 1st at 8h. 12m. P.M., with a southern declination of 2° 7′, and an apparent equatorial diameter of 18·3″ (the major axis of the ring system being 43″ in diameter, and the minor 6⅓″). On the 31st he rises at 6h. 2m. P.M., with an apparent equatorial diameter of 19″ (the major axis of the ring system being 43½″ in diameter, and the minor 5½″). Saturn will be occulted by the Moon on the 4th, but the phenomenon will only be visible in the southern hemisphere. He will also occult a 9½ magnitude star on March 12th, central occultation taking place at 9h. 32m. P.M. This will, of course, be visible in England. Dione is in inferior conjunction at 8·2h P.M. on the 2nd; Rhea in superior conjunction at midnight on the 4th; Dione is in inferior conjunction at 1·1h. A.M. on the 11th; Rhea is in superior conjunction at 0·7h. A.M. on the 13th; in inferior conjunction at 7·2h. P.M. on the 20th; in superior conjunction at 1·4h. A.M. on the 23rd; Iapetus is in inferior conjunction at 8·5h. P.M. on the 24th; Rhea is in inferior conjunction at 7·8 P.M. on the 29th. During March, Saturn describes a retrograde path from 38 to the east of γ Virginis.

Uranus is an evening star, rising on the 1st at 11h. 5m. P.M., with a southern declination of 14° 35′, and an apparent diameter of 3·7″. On the 31st he rises at 9h. 2m. P.M., with a southern declination of 14° 20′. During the month he describes a retrograde path in Libra, through a region barren of naked eye stars.

Neptune is still visible, and sets on the 1st at 1h. 44m. A.M., with a northern declination of 20° 13′, and an apparent diameter of 2·6″. On the 31st he sets at 11h. 48m. P.M., with a northern declination of 20° 19′. During the month he describes a short direct path in Taurus to the west of the 5¾ magnitude star, Weisse's Bessel², iv. h. 650. A map of the small stars near his path will be found in the *English Mechanic* for October 28th, 1892.

There are no very well marked shooting stars in March. The zodiacal light should be looked for in the west on every moonless evening.

The Moon is full at 4h. 3m. P.M. on the 2nd; enters her last quarter at 5h. 13m. P.M. on the 10th; is new at 4h. 33m. A.M. on the 18th; and enters her first quarter at 9h. 34m. P.M. on the 24th. She is in apogee at midnight on the 8th (distance from the earth 251,330 miles), and in perigee at 7h. P.M. on the 20th (distance from the earth 226,620 miles).

Chess Column.

By C. D. Locock, B.A.Oxon.

ALL COMMUNICATIONS for this column should be addressed to the "CHESS EDITOR, *Knowledge Office*," and posted before the 10th of each month.

Solution of February Problem (by A. F. Mackenzie):—

Key-move: 1. B to KR7.

If 1. . . . R × Q, 2. R to B7, &c.
If 1. . . . R × Kt, 2. Q × R, &c.
If 1. . . . R to Q7, 2. Kt × Pch, &c.
If 1. . . . R to B7, 2. Kt × Rch, &c.
If 1. . . . R to K8, 2. Kt to B2ch, &c.
If 1. . . . P to Kt7, 2. Q to R2, &c.
If 1. . . . P to R6, 2. Q × P, &c.
If 1. . . . P to Kt5, 2. R to B4ch.
If 1. . . . Kt moves, 2. Q to K4 mate.

CORRECT SOLUTIONS received from Alpha, A. G. Fellows, R. A. B., W. T. Hurley, and A. Rutherford. Additional correct solution of January Problem from S. V. Mott.

C. T. Blanshard.—Apart from duals in the 1. . . . P to B4 variation (*e.g.*, 3. Kt to R4, and 2. P to QKt4), your problem may be solved simply by 1. Q to B5.

A. G. Fellows.—Thanks for the problem, which we reserve for next month, a two-mover being now due.

PROBLEM.

By W. A. CLARK, East Molesey.

First Prize in Liverpool *Weekly Mercury* Tourney.

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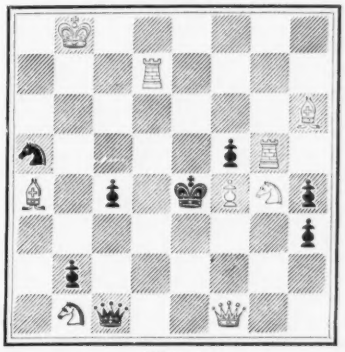

WHITE.

White to play, and mate in two moves.

The following game was played in the North *v.* South match at Birmingham. To save space, the opening moves are omitted:—

Position after Black's 27th move.

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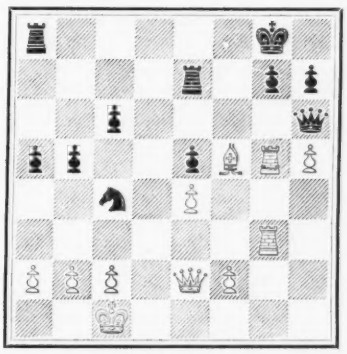

WHITE.

WHITE (Rev. W. E. Bolland).	BLACK (W. H. Pullinger).
28. P to Kt3	28. Kt to Kt3?
29. Q to K3!	29. Q to Q3 (*a*)
30. Q × Kt	30. P to R5
31. Q to K3 (*b*)	31. Q to R6ch (*c*)
32. K to Ktsq	32. R to Qsq
33. Q to Bsq (*d*)	33. Q to Kt5
34. P to R3 (*e*)	34. Q to B4
35. R to Q3	35. R × R
36. P × R	36. Q × P
37. P to Kt4 (*f*)	37. Q to B6
38. Q to B2	38. Q to K6

39. R to Kt2	39. R to QB2 (*g*)
40. B to K6ch	40. K to Rsq
41. R to B2 (*h*)	41. P to R3 ? ?
42. R to B8ch	42. K to R2
43. B to B5ch ? (*i*)	43. P to Kt3
44. P × Pch (*j*)	44. K to Kt2
45. R to B7ch	45. R × R
46. P × R	46. K × P
47. B to Q7	47. P to R4
48. B × P (*k*)	48. P to R5
49. B × P	49. P to R6
50. Q to KR2 (*l*)	50. Q to K8ch
51. K to B2	51. Q to B8 (*m*)
52. Q × KP	52. Q to B7ch (*n*)
53. K to B3	

Adjudicated a win for White (*o*).

Notes.

(*a*) It was better to move the Knight, giving up the Queen and probably two Pawns for the two Rooks, *e.g.*. 29. . . . Kt to Q2 ; 30. R × Pch, Q × R ; 31. Q to R6, Q × R ; 32. P × Q, Kt to KBsq, &c., with better prospects than in the actual game.

(*b*) Much better than 31. R to Q3, which Black could answer either by 31. . . . Q to R3 ; 32. P to KB4 ? P × P ; or by 31. . . . Q to R6ch, which, however, is probably not so good. The text move prevents 32. . . . P × P.

(*c*) This and his next move are mistakes. He should play 31. . . . P × P.

(*d*) Not so forcible as 33. R × Pch, K to Rsq ; 34. Q to Q2 !—a resource which not only saves the game but wins it on the move, for the Queen goes next to R6, forcing mate.

(*e*) R × Pch was again quite feasible ; so also on the next move. White's line of play not only loses a Pawn, but by exposing his King's position increases the chances of a draw.

(*f*) 37. Q × P was safe enough and more vigorous. White probably feared the reply . . . P × P, which would lose the Queen by 38. Q to B8ch, K to B2 ; 39. B to K6ch, &c.

(*g*) In order to advance the QBP ; but he has no time, and should therefore withdraw the Queen to KR3.

(*h*) Not nearly so strong as 41. Q to Q2, Q to Q5 ; 42. P to R6 ! P to Kt3 ; 43. Q to Kt5, and wins.

(*i*) Strangely overlooking the mate in three moves.

(*j*) A safer line of play would be B × Pch followed by R to Q8. The exchange of Rooks and subsequent gain of Pawns was no doubt tempting, but it leaves Black with a dangerous passed Pawn.

(*k*) 48. Q to Qsq is an alternative here.

(*l*) It is difficult to say whether 50. Q to B7ch, K to B3 ; 51. Q to Q8ch ! is better or not than the course adopted. Probably both are good enough.

(*m*) Threatening 52. . . . Q to Kt7ch. White's reply is forced.

(*n*) 52. . . . Q to Kt7ch ; 53. K to B3, P to R7 loses the Queen by 54. B to B4ch, K to Kt3 (or mate in two) ; 55. Q to K8ch ! K to B3 (best) ; 55. Q to K6ch, &c.

(*o*) For if 53. . . . P to R7 ; 54. B to B4ch, K to Bsq (otherwise White changes Queens, followed by B to Q5) ; 55. Q to R8ch, K to K2 ; 56. Q to Kt7ch, K to Qsq (if the King play to Q3 instead, White forces the game by checking with the two Pawns, followed by Q to Kt6ch) ; 57. B to K6 (or A), K to Ksq (best) ; 58. B to Q7ch ! K to Qsq ; 59. B to B5 ! K to Ksq ; 60. Q to Kt8ch, K to K2 ; 61. Q to K6ch, K to Bsq ; 62. Q to B6ch, and wins.

(A) 57. B to Kt5, Q to K8ch ? (or 57. . . . K to Bsq ! 58. Q to Q7ch, K to Ktsq ; 59. Q to Q6ch, K to Kt2 (best) ; 60. B to B6ch ! K to R3 ; 61. B to Q5 dis ch, Q to Kt3 ; 62. P to K5 and wins) ; 58. K to B4, Q to B8ch ; 59. K to Q5, Q to Bsq ; 60. Q to B8ch, K to B2 ; 61. Q to Q6ch, and wins.

CHESS INTELLIGENCE.

The long-expected match between the North and South of England was decided at Birmingham on January 28th. There were 106 players on each side, those reserve men who were not required in their special capacity being paired against one another. After a most exciting match the Southern team scored a hard-earned victory with a score of 53⅓ to 52⅔. It is remarkable that if there had been only 100 players a side the result would have been a tie ; so also before the adjudication of unfinished games the score was exactly even ; and if one of these latter had been adjudicated in accordance with the subsequently expressed views of some experts the result would also have been a tie. In spite, however, of the closeness of the result it would appear that the South is really the stronger side. On the first 20 boards, which should furnish a sufficient test, they did not lose a single game, except at board No. 11, where two reserve men were opponents. That the North should have done so well at the other boards may be perhaps accounted for by the fact that the Southern team was not quite representative. Arrangements are in progress for a return match to be played in London next autumn.

The honorary secretary of the West London Chess Club informs us that the club now meets on Monday and Thursday evenings at the Holland Park Club, 3, Norland Place, W.

A new chess club has been started at Clapton under the title of the Lonsbury Chess Club. The club meets on Wednesday evenings at Lonsbury College, Nightingale Road.

Mr. Lasker is now at Havana, where he has defeated the two leading players of the Havana Chess Club, Señor Golmayo and Señor Vasquez, in short matches. Mr. Lasker did not lose a game in either match. The great event of his visit will be the match with Herr Walbrodt, of Berlin.

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